NASA Technical Memorandum 82635

SEP Bimod Variable Conductan s Acceptance and Characterizatio

Joseph A. Hemminger
Lewis Research Center
Cleveland, Ohio

August 1981

NASA

National Aeronautics and
Space Administration

Lewis Research Center
Cleveland, Ohio
44135

NASA

Reply to Attn of: 1943

September 10, 1981

TO: Distribution

FROM: 1900/Chief, Management Services Division

SUBJECT: NASA Technical Memorandums

Enclosed are copies of Lewis Technical Memorandums for your information and library use.

Please direct them to the attention of the members of your technical staff who may be interested in the subjects.

George Mandel

Distribution:
Installation Libraries

Ames Research Center
Hugh L. Dryden Flight Research Center
Goddard Space Flight Center
Jet Propulsion Laboratory
John F. Kennedy Space Center
Langley Research Center
Lyndon B. Johnson Space Center
George C. Marshall Space Flight Center
Wallops Flight Center

TABLE OF CONTENTS

1.0 SUMMARY

A series of six heat pipes, similar in design to those flown on the Communications Technology Satellite Hermes, were fabricated and tested by TRW Space Systems Group for use by NASA Lewis Research Center in a prototype Solar Electric Propulsion BIMOD thrust module. This report documents the results of acceptance and characterization tests performed on the heat pipe subassemblies following their delivery to NASA. The performance of all the heat pipes met, or exceeded, design specifications.

2.0 INTRODUCTION

As part of its Technology Readiness Program for Solar Electric Propulsion (SEP), NASA Lewis Research Center designed and built a prototype SEP BIMOD* thrust module. One of the primary goals of this effort was to minimize the individual weights of primary system components. For the two Power Processing Units (PPU's) in the BIMOD assembly, this was done through an integrated evaluation of thermal control and structural requirements. The resulting design (which is documented in detail in reference 1) called for the use of six variable conductance heat pipes to transport 410 watts of waste heat from each of the two PPU's to the two space-facing radiator panels. The heat pipes used, similar in design to those used on the Communications Technology Satellite (CTS) Hermes, were built and tested by TRW's Space Systems Group (reference 2). Prior to assembly into the "live" BIMOD configuration, the individual heat pipe subassemblies were subjected to acceptance and characterization tests at Lewis (1) to verify that their performance met design specifications, and (2) to provide reference data to compare with data taken in expected tests of the live BIMOD assembly. This report documents the hardware used in, and the results of, these tests.

---

*The name BIMOD is derived from the bi-modular nature of the assembly, which contains two PPU's, two 30-cm ion thrusters, and two thermal control radiator panels.

3.0 DESCRIPTION OF THE HARDWARE TESTED

TRW provided the six heat pipes to NASA in two modular configurations, designated A and B. Each module consists of three heat pipes soldered into two aluminum evaporator saddles. The two evaporator saddles differ according to the pattern of holes (with plate-nuts) used to attach PPU electrical components. Their most differentiating feature, however, is the presence on one of the saddles (Appendix B, NASA Drawing CF 637022) of an extra tab which provides an additional heat flow path for two high dissipation inductors in the PPU A-3 module. The other saddle (NASA Drawing CF 637023) does not have such a tab. "Saddle with tab" and "saddle without tab" is used to differentiate the two evaporator saddles throughout this report.

A plan view of the module subassemblies is shown in Figure 3.1. They differ according to: (1) the orientation of the two evaporator saddles on the assembly, and (2) which end of the saddles the condenser sections of the individual heat pipes exit. Figure 3.2 is a schematic of the heat pipe cross-section and Table 3.1 gives details of its mechanical configuration. Figure 3.3 is a photograph of the Module A configuration.

FIGURE 3.1 SEP BIMOD Heat Pipes: Plan & End Views of Module Subassemblies

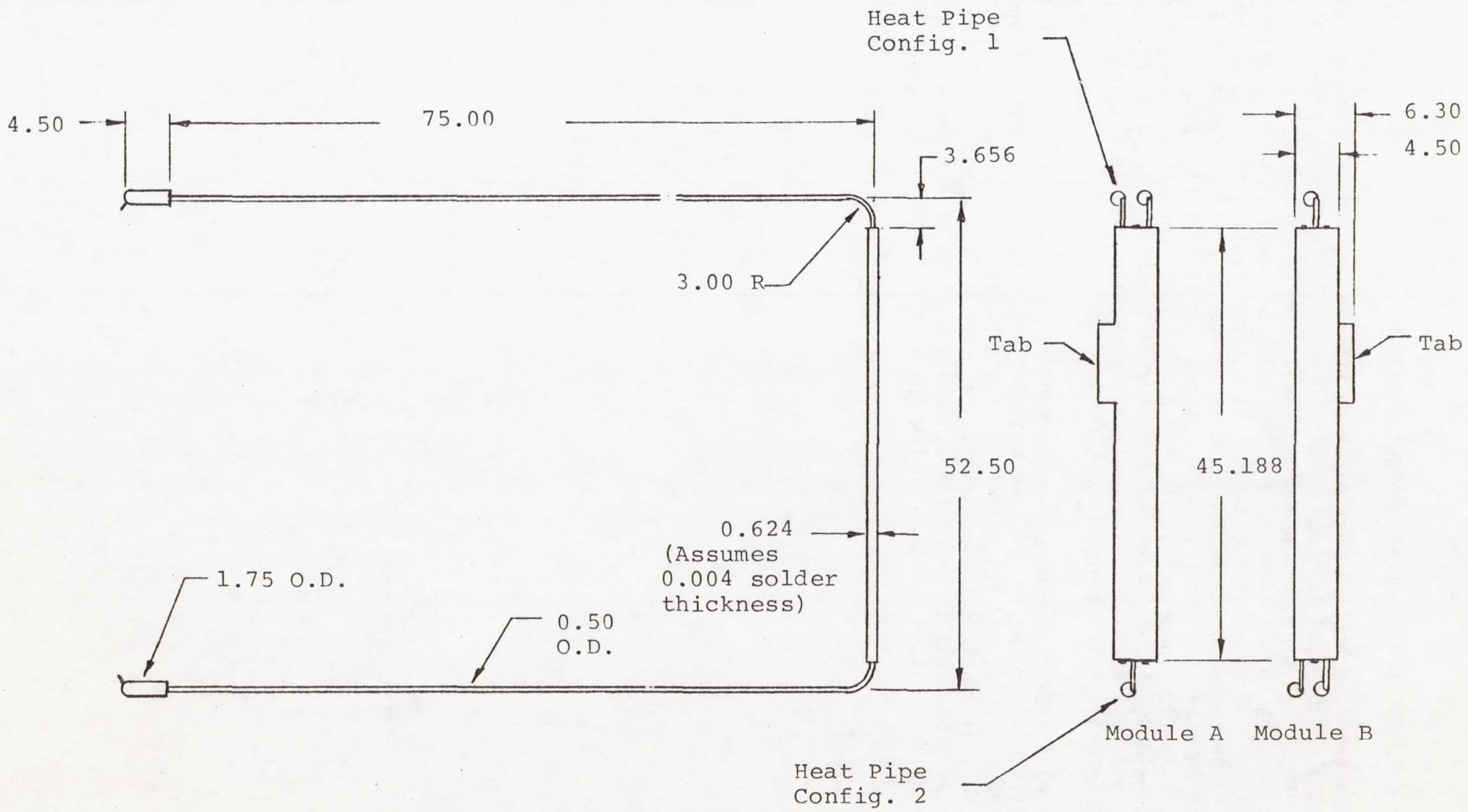


FIGURE 3.2 SEP BIMOD Heat Pipe Cross-Section Schematic

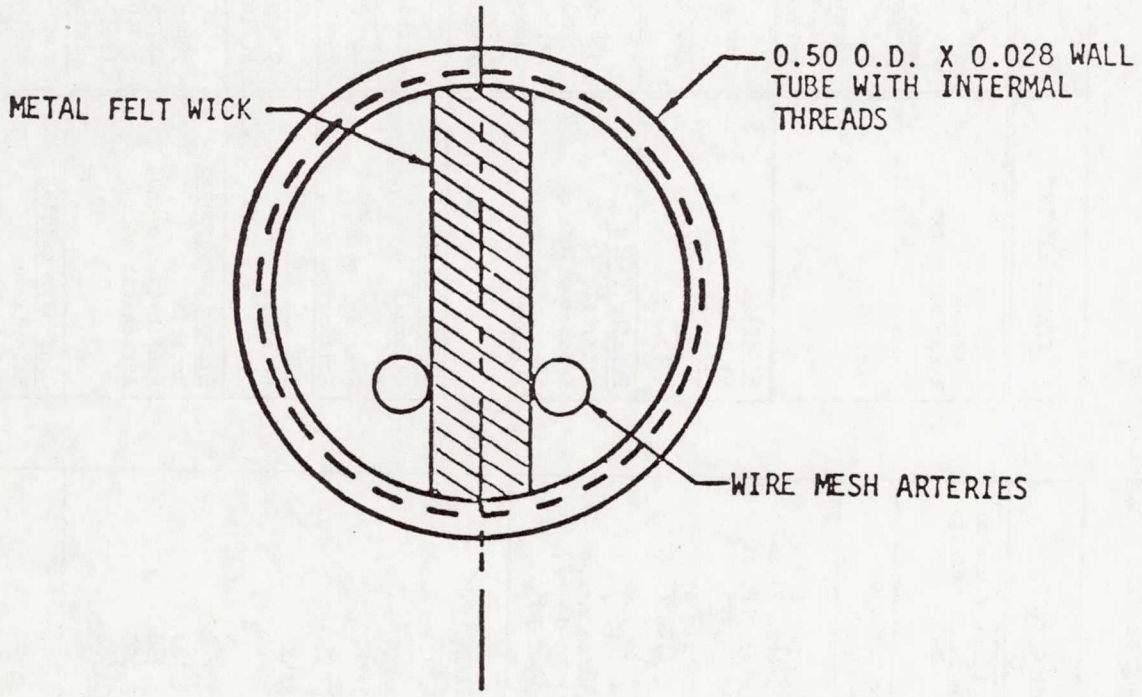
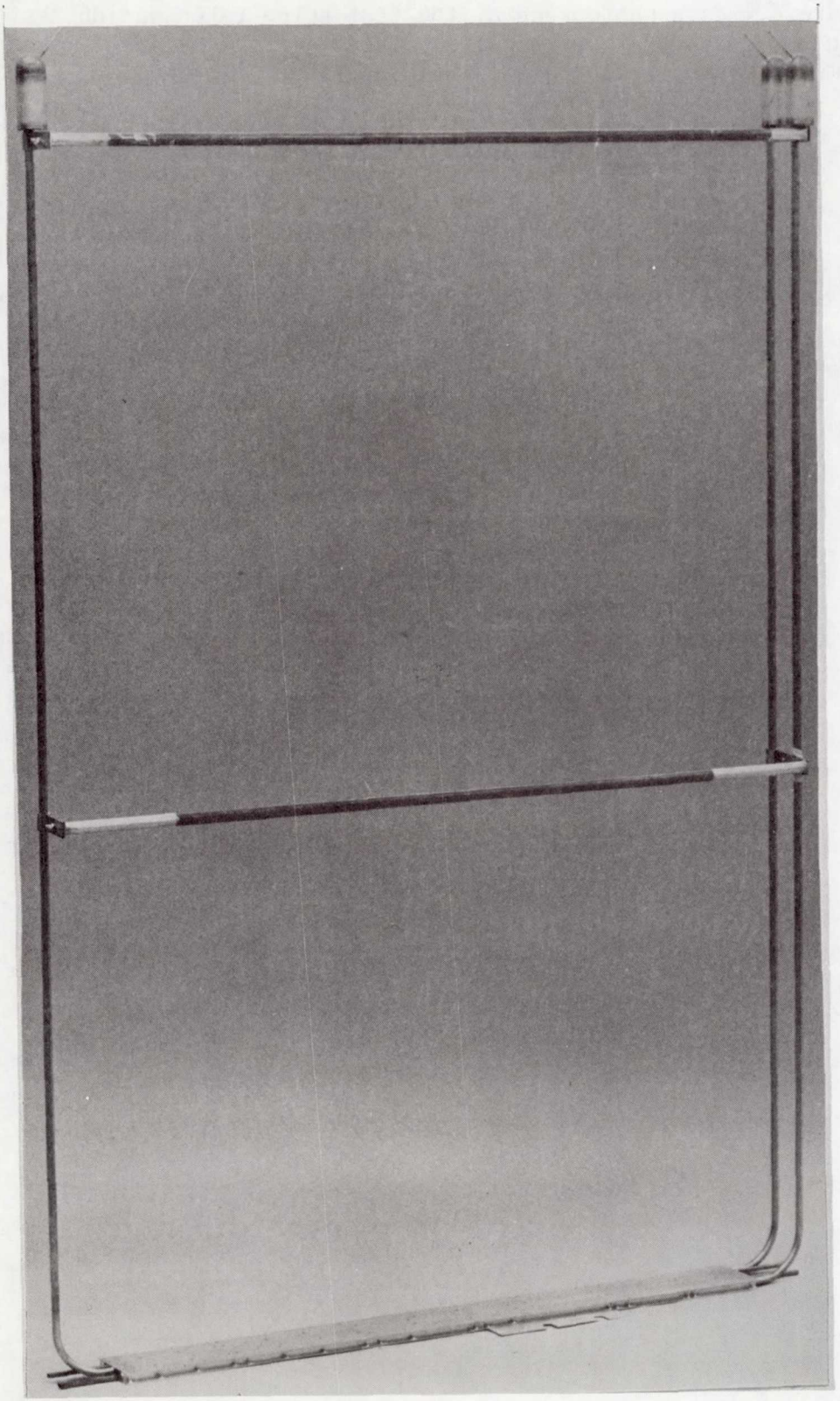


TABLE 3.1 Physical Details of CTS and SEP Variable Conductance Heat Pipe Systems

CHARACTERISTIC	CTS VCHPS	SEP BIMOD VCHPS
Function	Control temperature of TEP OST and PPS (in parallel with South Panel)	Control temperature of PPU's in BIMOD configuration
Number of heat pipes	Three per spacecraft	Three per PPU, or six per BIMOD
Thermal		
System capacity	196 watts min at $T_e \geq 50°C$ (122°F) and <3 watts at $T_e < 10°C$ (50°F)	410 watts per PPU at $T_e \geq 50°C$ (122°F) and <3 watts per PPU at $T_e < 10°C$ (50°F)
Heat pipe capacity	Nom. 150 watts min at $T_e \geq 50°C$ (122°F) and <1 watt at $T_e < 10°C$ (50°F)	220 watts min at $T_e \geq 50°C$ (122°F) and <1 watt at $T_e < 10°C$ (50°F)
Heat pipe power factor	7500 watt-inches	14,000 watt-inches
Temp. control range	21-48°C (70-118°F)	33-47°C (91-117°F)
Max. off. sink temp.		-75°C (-102°F)
Tubes		
Material	304 stainless steel, fully annealed (σ_y = 35,000 psi; σ_u = 75,000 psi)	SAME
Cross-section	0.500 OD x 0.028 wall	SAME
Internal threads	100 TPI, 0.005 deep, 40° included angle	SAME
Free vol/length ratio	.1027 in^3/in	SAME
	#1 #2 #3	
Total length	68.00 74.86 79.78	122.556
Evap. section length	22.00 22.00 22.00	45.188
Adiab. section length	3.70 3.70 3.70	5.368
Cond. section length	42.30 49.16 54.08	72.000
Effective length $((L_e+L_c)/2)+L_a$	35.85 39.28 41.74	63.962
Reservoirs		
Material	304 stainless steel	SAME
Configuration	Spun hemispherical cap with 1.75 OD cylindrical center section	SAME
Free volume	8.22 in^3	SAME

CHARACTERISTIC	CTS VCHPS	SEP BIMOD VCHPS
Wicks		
Material	304 stainless steel	SAME
Reservoir wick	0.020 thick (spot-welded to interior walls)	SAME
Tube wick	0.050 thick (interference fit across dia. of tube; one splice required	SAME
Arteries		
Material	316 stainless steel	304 stainless steel
Cross-section	0.063 ID x $(150)^2$ mesh (0.0026 dia. wire)	0.070 ID x $(150)^2$ mesh (0.0026 dia. wire); one splice required
Priming foils		
Material	304 stainless steel	SAME
Cross-section	0.063 ID x 0.0005 wall with 0.010 dia. holes	0.081 ID x 0.00027 wall with 0.006 dia. holes
Attachment	Spot-welded to end of arteries and diametral wick	Welded over window in end-cap; end-cap welded to end of artery.
Working fluid		
Material	Methanol (Spectrophotometric grade)	SAME
Freezing point	-98°C (-144°F)	
Boiling point	65°C (149°F)	
Control gas		
Material	90% nitrogen, 10% helium (research grade)	SAME
Evaporator saddles		
Material	6061-T6 aluminum alloy	SAME
Fabrication method	Extruded	Machined or extruded
Attachment	60-40 tin/lead solder (following Cu/Ni/Sn plating)	SAME
Condenser saddles		
Material	6061-T6 aluminum alloy	SAME
Fabrication method	Extruded	Formed sheet (also serves as radiator stiffeners)
Attachment	60-40 tin/lead solder (following Cu/Ni/Sn plating)	RTV-566 and bolts to radiator

FIGURE 3.3 SEP BIMOD Heat Pipes: Module A Subassembly



4.0 DESCRIPTION OF TEST EQUIPMENT AND SETUP

Figure 4.1 is a photograph of the test setup taken during tests on the Module B configuration hardware. Specifics of the major mechanical elements of the test equipment include the following.

1. Separate, resistance-type heaters were attached to each side of the evaporator section of the heat pipes to simulate the separate heat input from each PPU in the BIMOD configuration. As shown in Figures 4.2.1 and 4.2.2, heater no. 1 was attached to the evaporator saddle with the tab, and heater no. 2 to the saddle without the tab. The entire evaporator/heaters assembly was enclosed in styrofoam balls which were contained within multi-layer insulation (MLI) blankets.

2. Dual-groove aluminum saddles enclosed both the condenser section of each heat pipe and a copper tube through which fluid from a constant temperature bath (CTB) could be circulated. These saddles were left exposed to the ambient air environment.

3. Aluminum saddles with resistance-type heaters, and a stainless-steel jacket (enclosed in MLI) through which cold GN2 could be circulated, surrounded each heat pipe gas reservoir. GN2 was cooled by flowing it through a copper coil immersed in LN2. Locations of the heaters (numbered 3, 4, and 5) are shown in Figures 4.2.1 and 4.2.2).

4. A test stand with leveling screws on each leg, and a tilting top-frame to which the heat pipe subassembly was attached, provided the tilt adjustment capability required to adjust the gravity-head on the heat pipes.

5. Over-heating protection was provided. A dedicated thermocouple sensing evaporator heater temperature was used to activate relays to shut off heater power when the evaporator temperature exceeded a nominal 150°F (66°C).

FIGURE 4.1 SEP BIMOD Heat Pipe Acceptance and Characterization Tests: Hardware Setup

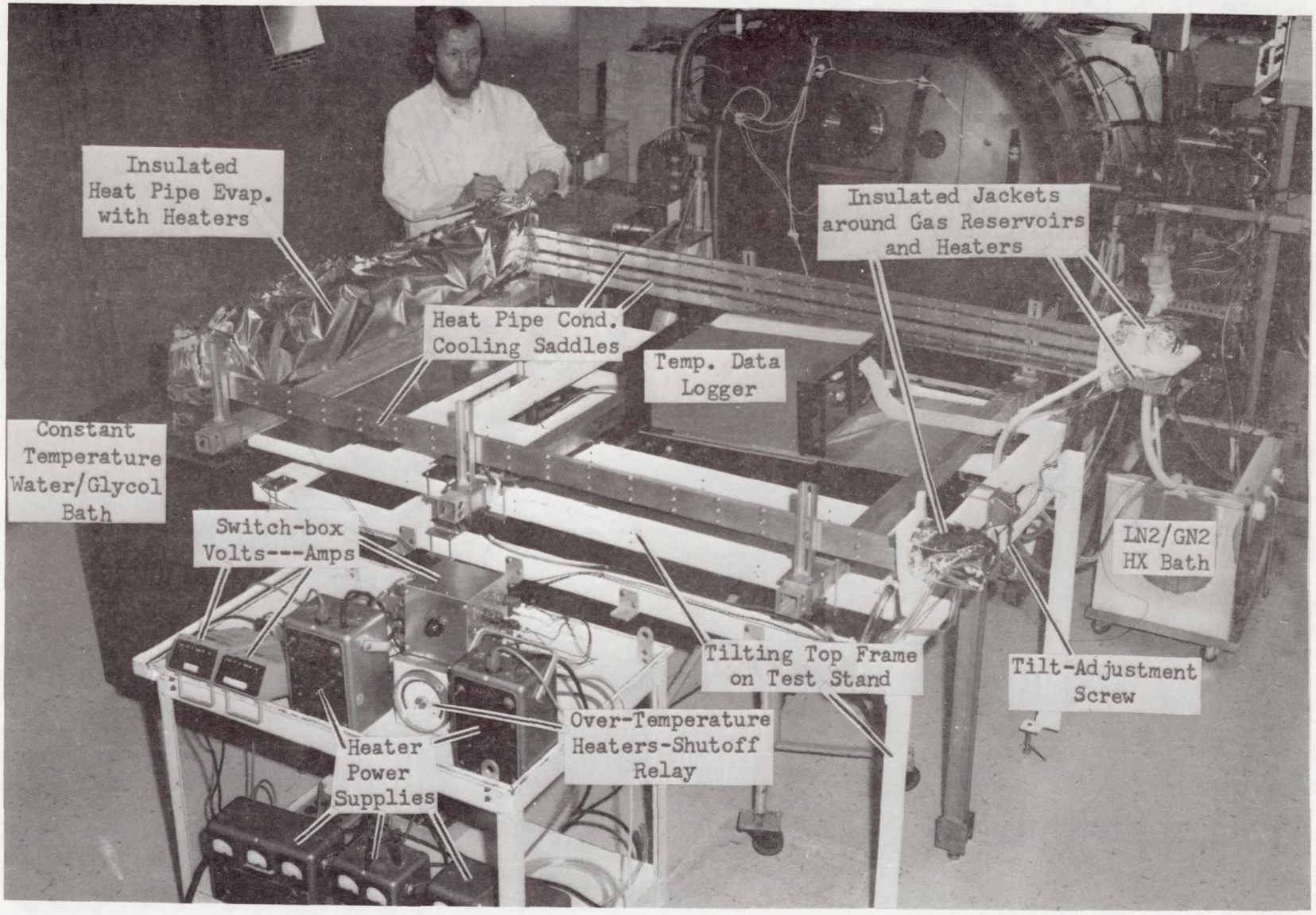


FIGURE 4.2.1 Thermocouple Instrumentation Layout for Module A Configuration

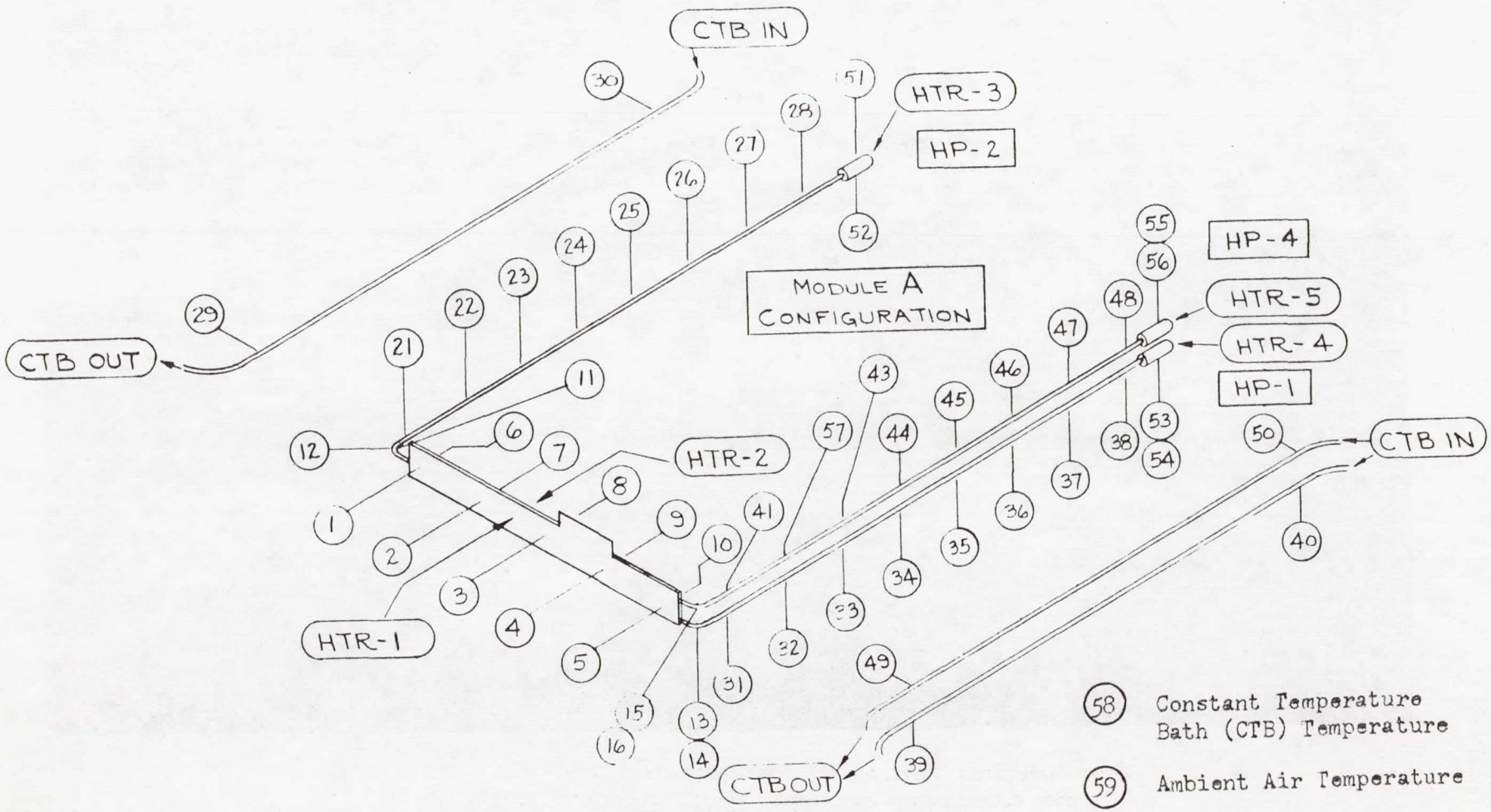
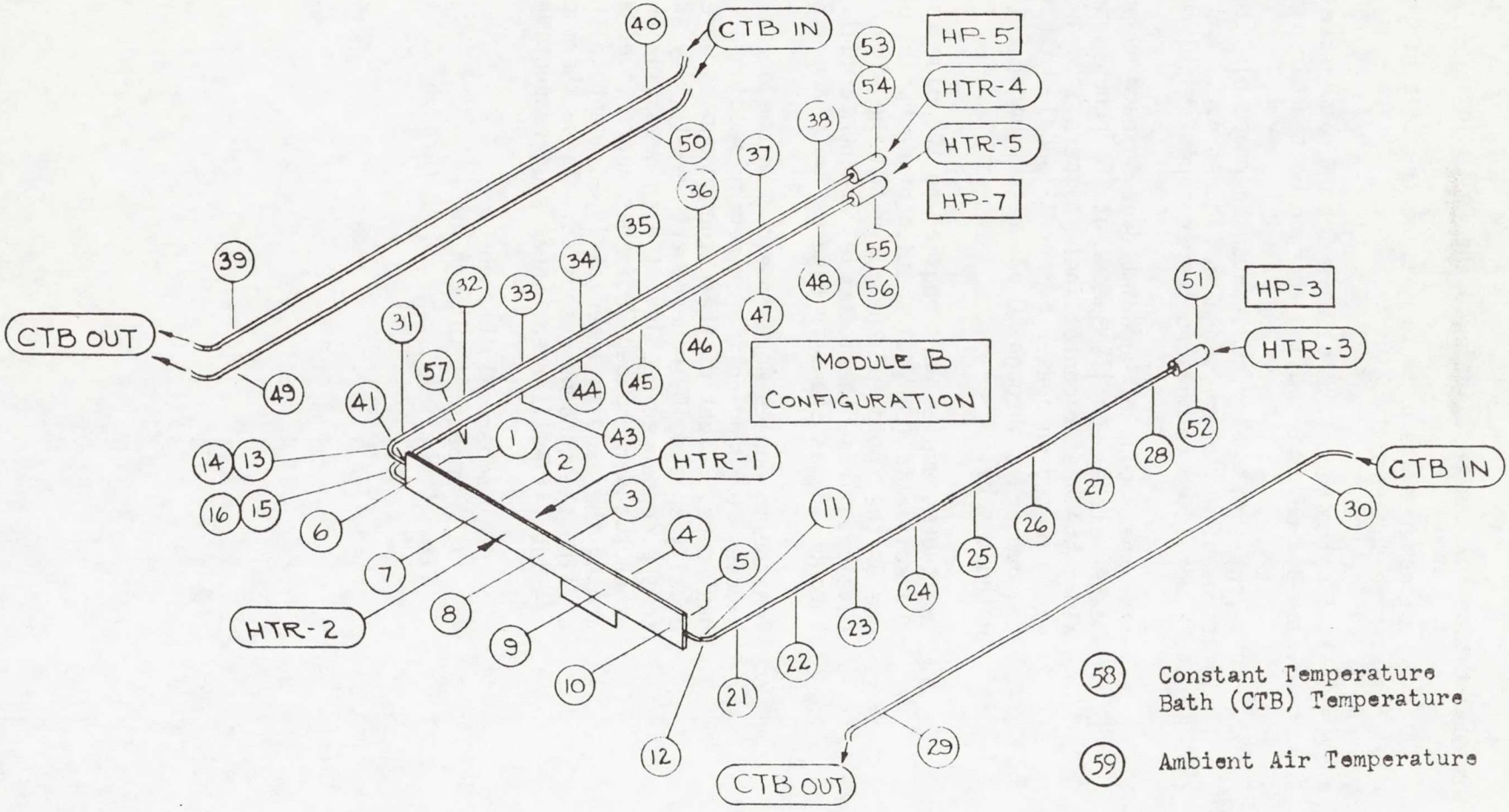


FIGURE 4.2.2 Thermocouple Instrumentation Layout for Module B Configuration



Instrumentation for the test included the following:

1. An inclinometer was used to measure the tilt of the heat pipe subassembly.

2. Digital voltmeters (DVM's) were set up to measure voltage and current applied to each heater circuit.

3. Fifty-four (54) copper/constantan thermocouple (the locations of which are shown in Figures 4.2.1 and 4.4.2) were used to measure temperatures as follows.

   a. Five thermocouples were imbedded in each evaporator heater plate, equally spaced at 10 inches apart along the heater centerline. Numbers 1 through 5 were mounted on heater number 1 (saddle with tab) and numbers 6 through 10 on heater number 2 (saddle without tab).

   b. Two thermocouples were epoxied to the pipe wall of the adiabatic (curved) section of each heat pipe, one on the inside of the curve and the other on the outside. These thermocouples are numbered 11 through 16, as shown in Figures 4.2.1 and 4.2.2.

   c. Ten thermocouples were imbedded in one of the two saddles surrounding the condenser section of each heat pipe. Eight of these thermocouples were equally spaced 10 inches apart immediately adjacent to the condenser section of each heat pipe and the other two were spaced 70 inches apart (i.e. at each end of the saddle) immediately adjacent to the tube cooling the condenser saddles. These thermocouples are identified (for each heat pipe respectively) as:

      i. Numbers 21 through 30
      ii. Numbers 31 through 40
      iii. Numbers 41, 57, and 43 through 50

d. One thermocouple was imbedded in each of the two heater saddles on each heat pipe gas reservoir. These thermocouples are numbered 51 through 56, as shown in Figures 4.2.1 and 4.2.2.

e. One thermocouple (number 58) was inserted in the fluid in the constant temperature bath (CTB) reservoir.

f. One thermocouple (number 59) measured the temperature of the ambient air under the test stand.

Temperatures were recorded using a DORIC Digitrend (Model no. 210-100-0104 ((10 mv))-05-09; serial no. 5435; NASA LeRC property number 113122). Figures 4.2.1 and 4.2.2 show the location of the thermocouples for each of the two (2) module configurations tested and the Digitrend channels on which they were recorded.

5.0 TEST PLAN

The primary purpose of these tests was to verify that the heat pipe manufacturing specifications were met. The parameters explored for each heat pipe included its turn-on and full-on temperatures and its maximum heat transport capacity.

Secondarily, the tests were run to determine system operating characteristics, both those defining heat pipe operating limitations and those peculiar to the BIMOD configuration, which might be of value during future testing and design efforts involving such heat pipes. These latter tests included: (1) determining the heat transport capacity of a heat pipe module configuration when operating with all arteries deprimed (this parameter could be of value when ground test or flight environment conditions might cause artery depriming; throttling power consumption to this value would allow for continued operation until an orderly thermal recycling can be effected to reprime the arteries), (2) determining the temperature differential across the heat pipe evaporator when only one PPU is operating (this parameter gives an indication of the quality of thermal interface joints and saddle cross-section design in transferring heat from a PPU to the heat pipes), and (3) determining the effect of changing condenser sink temperature on heat pipe performance (this parameter is useful in determining the effect on performance resulting from varying radiator size, thickness, and sink temperatures resulting from operating in different environments, e.g., space vs. test chamber cold walls, etc.).

6.0 TEST PROCEDURE

Prior to each test run, the heat pipe system was tilted so that a 2- to 3-inch head caused the heat pipes to deprime. The system was then re-leveled and the heat pipes were given time to reprime. During actual application of heat to the heat pipe evaporators, the system was tilted slightly (the evaporator end being higher than the condenser end) so that the heat pipes were working against a 0.30-inch gravity head. This configuration worked to minimize the positive effect that gravity head has on heat pipe performance, thereby resulting in test data that was more representative of what expected zero-g performance should be.

For each heat pipe that would be operated during the test run, its gas reservoir was cooled to -100 ± 10°F (-73 ± °C), its specified effective sink temperature. For each heat pipe that was to be turned off, enough power was applied to its gas reservoir heater to maintain a temperature of 130 ± 10°F (54 ± 6°C). During the test run, this temperature was increased when required, to keep it approximately 5°F (3°C) above the maximum evaporator temperature.

The best turn-on and full-on temperature data was obtained when simultaneously operating all three heat pipes in a module configuration. The turn-on temperature was defined as the average adiabatic temperature when evaporator temperatures had risen to or above 80°F (27°C) and the nearest condenser temperature was within 5°F of this average adiabatic temperature. The full-on temperature was defined as the average adiabatic temperature at the time the system reached thermal equilibrium with 200 watts per operating heat pipe applied to the evaporator heaters and the temperature of the constant temperature bath (CTB) used to cool the condenser saddles set at approximately 112°F* (44°C). The procedure for obtaining this data was as follows: A total of 60 watts was initially applied to the evaporator heaters and temperatures were recorded at approximately 5-minute intervals. When the evaporator approached the turn-on temperature, data was taken at approximately 2-minute intervals. Once the turn-on temperature was determined, the heat applied to the evaporator was increased to 600 watts (which provided the rated 200 watts input to each heat pipe). When the evaporator heaters approached the full-on temperature condition, flow from the constant temperature bath (CTB) to the condenser cooling tubes was initiated. This procedure was necessary because the condenser saddles did not have adequate surface area to convectively cool the condenser.

---

*This was the estimated sink temperature required to draw 220 watts of heat through the saddles, etc., cross-section when the heat pipe is running at approximately 125°F (52°C) as indicated by the adiabatic section temperature.

Once the full-on temperature was determined, power to the evaporator was increased in 10-and/or 20-watt steps until one of the heat pipes deprimed, resulting in thermal runaway of the system. The maximum capacity of a heat pipe system (module) was defined as the highest evaporator heater power setting at which the evaporator temperatures did not indicate a thermal runaway condition.

When capacity tests were run on individual heat pipes, the power applied to the evaporator heaters after the turn-on temperature was reached was 220 watts. Power was increased in 10- and/or 20-watt increments until the operating heat pipe deprimed or evaporator temperature limits were exceeded. The maximum capacity of a heat pipe was defined as the highest evaporator heater power setting at which the operating heat pipe was not deprimed.

The arteries-deprimed capacity test of a heat pipe module was conducted following the arteries-primed capacity tests. Once one heat pipe deprimed due to excessive load, the remaining ones were forced to deprime by: (1) applying an approximately 2 1/2-inch gravity head (by tilting the unit), (2) initially applying a high heat load to the evaporator and then continuously adjusting the load to keep temperatures under the 150°F (66°C) maximum limit, and (3) mechanically jarring the test assembly. The maximum capacity of the module with all arteries deprimed was defined as that power at which the 150°F (66°C) maximum temperature on the evaporator could be maintained.

The ΔT across the evaporator with only one heater on (to simulate only one PPU operating) was determined during two of the arteries-primed capacity tests. For the Module A unit, a load of 330 watts was alternately applied to each of the two evaporator heaters and the temperature distribution determined when the system came to equilibrium. For the Module B unit, 480 watts was alternately applied to the evaporator heaters.

Determining the effect of changing sink temperature on heat pipe performance was done only with the Module A unit. The constant temperature bath (CTB) was lowered in temperature to -1.7°F (-18.7°C), then in sequence, 660 watts was applied to the evaporator heaters and flow was initiated from the CTB to the condenser cooling tubes. The heat being transmitted from the evaporator through the heat pipes to the CTB fluid was more than the CTB refrigerating unit could handle and, therefore, the 17.5 gallons of fluid slowly rose in temperature. The CTB fluid temperature was allowed to rise until one heat pipe deprimed, terminating the test.

7.0 TEST RESULTS

An overview summary of the results of these tests is presented in Table 7.1. The schedule according to which the tests were run (which also indicates the sequence with which the detailed data is presented in Appendix A) is outlined in Table 7.2.

Table 7.3 presents the turn-on and full-on temperatures of the individual heat pipes and compares the results with those obtained by TRW during their acceptance testing of the heat pipes following manufacture. These temperatures represent an average of the values determined from all the tests in which a particular heat pipe was operated in its primed state. The slight differences between these and TRW's results can be attributed to combined tolerances in test equipment and minor differences in test procedures and interpretation of results. For example, TRW determined turn-on temperatures with 220 watts applied to the evaporator; these tests were initially run with 60 watts applied to the evaporator to enable the Digitrend unit to record the turn-on data. Also, TRW used a thermocouple mounted at the end of the evaporator opposite the condenser to define turn-on and full-on temperatures; these tests used the adiabatic section temperatures to define these values because all the evaporator thermocouples were mounted on the heater plates, which saw a ΔT between the plate and saddle resulting from the interface RTV joint and which varied according to the power applied to the evaporator heaters.

Table 7.4 presents turn-on and full-on temperatures taken during arteries-deprimed tests of each module configuration with simultaneous operation of all three heat pipes. Note that the turn-on temperatures are slightly higher than for the primed condition. The full-on condition, which was defined as the maximum power at which the maximum evaporator temperature is 150°F (66°C) or less, shows a configuration sensitivity. Both the individual evaporator heater elements and the thermocouples indicating evaporator temperatures were located along the centerline of the saddles, that is, closest to the center heat pipe (S/N-2 and S/N-3) in the evaporator configuration. As a result, at the low power levels at which these tests were run, the center heat pipe ran hotter, thereby carrying a greater share of the applied load.

TABLE 7.1 Summary of Results of Heat Pipe Tests

Goals	Spec.	Results
Verify for invididual heat pipes		
Turn-on temperature	100°F	98 to 101°F
Full-on temperature	>122°F	123 to 125°F
Verify heat transport capacity of	Min. of	
Individual heat pipes	220 watts	260 to >320 watts
Three heat pipe Arteries primed	>660 watts	760 and 940 watts
subsystems Arteries deprimed	---	85 and 110 watts
Determine evaporator temperature profile with one PPU operating	---	ΔT_{evap} at P_{evap} 6.8,7.6°F 480 watts 4.7,8.1°F 330 watts
Determine effect on heat pipe operating temperature resulting from changing condenser sink temperature	---	Ratio = 0.24 °F/°F (over 10 to 105°F sink temp. range)

TABLE 7.2 Test Schedule

Module Configuration	Test Date	Heat Pipes Operating	Special Test Condition(s)
B	5-17-79	3,5,7	Arteries Primed
	5-21-79	3	Arteries Primed
	5-29-79	5	Arteries Primed
	5-30-79	7	Arteries Primed
	5-31-79	3,5,7	Arteries Deprimed
A	7-3-79	2,1,4	Arteries Primed
	7-19-79	2	Arteries Primed
	7-23-79	1	Arteries Primed
	7-24-79	4	Arteries Primed
	7-24-79	2,1,4	Arteries Deprimed
	7-25-79	2,1,4	Arteries Primed; varying sink temp.
	7-25-79	2,1,4	Arteries Primed (repeat of 7-3-79 test)

TABLE 7.3 Turn-On and Full-On Temperatures of SEP Heat Pipes (Arteries Primed)

Module Configuration	Heat Pipe Number	Temperature (°F)			
		Turn-On		Full-On	
		LeRC	TRW	LeRC	TRW
A	1	98	103	124	123
	2	101	103	123	121
	4	99	105	124	126
B	3	101	100	125	124
	5	100	100	123	125
	7	99	105	123	126

TABLE 7.4 Turn-On and Full-On Temperatures of SEP Heat Pipes (Arteries Deprimed)

Module Configuration	Heat Pipe Number	Temperature (°F)	
		Turn-On	Full-On
A	1	102	112
	2	105	115
	4	105	113
B	3	(Data Not Recorded)	115
	5	105	109
	7	105	105

Table 7.5 presents the maximum heat transport capacity data determined in these tests and compares the results with those obtained by TRW during testing of the heat pipes at the time of manufacture. It should be noted that the sum of the individual heat pipe capacities is greater than the capacity of the system when operated as a whole in both module configurations. The detailed thermal data shows why this takes place. As indicated in Figures 7.1 and 7.5, the adiabatic sections of Module A heat pipe S/N-4 and Module B heat pipe S/N-3 were running hotter than the other two heat pipes in their respective configurations, thereby indicating that they were encountering the highest thermal resistance relative to their applied loads. Also, as Table 7.5 indicates, their individual heat transport capacities are the lowest in their respective module configurations. Thus one would expect that these two heat pipes would deprime before the other two in the respective configurations reached their maximum capacity. The test results show that, indeed, such was the response. In Figures 7.2, 7.6 and 7.7, heat pipes S/N-4 and S/N-3 show a drop in temperature while the other heat pipes continue to rise in temperature. In the case of the Module A configuration, however, it appears that only one artery of heat pipe S/N-3 initially deprimed and that the other two heat pipes had sufficient excess capacity to compensate for its loss of capacity. As shown in Figures 7.3 and 7.4, only when additional power was applied to the evaporator heaters did heat pipe S/N-2 deprime and evaporator temperatures start running away.

Table 7.6 summarizes the results of the capacity tests of all three heat pipes in a module configuration when all their arteries are deprimed.

Figures 7.8 and 7.9 show the temperature profile of the Module B configuration when only one evaporator heater is operating at 480 watts.

Figures 7.10 and 7.11 show the Module A temperature profile when each evaporator heater is operated at 330 watts respectively.

Figure 7.12 shows a plot of varying CTB temperature vs. the corresponding adiabatic section temperatures of the heat pipes in the Module A configuration. The ratio indicated in Table 7.1 was derived from the data used to generate this figure.

Finally, the detailed temperature and heater power data has been cataloged in the figures included in Appendix A of this report. The data is presented in the form of computerized: (1) plots (which include descriptive notations of significant test events), and (2) schematics (which provide instantaneous temperature profiles at or near highlight points during the tests).

TABLE 7.5 Heat Transport Capacity of SEP Heat Pipes (Arteries Primed)

Module Configuration	Heat Pipe Number	Heat Transport Capacity (Watts) At Artery Depriming (Burnout)		
		Spec	LeRC	TRW
A	1,2,4	>660	760 [1]	---
	1*	>220	320	230
	2	>220	320	>310 [3]
	4*	>220	260	>300 [3]
B	3,5,7	>660	940 [2]	---
	3	>220	280	230
	5	>220	>300 [4]	300
	7	>220	>300 [3]	320

1 Heat pipe S/N-4 deprimed first.
2 Heat pipe S/N-3 deprimed first.
3 Testing terminated at this power level.
4 Test conditions resulted in other heat pipes in module carrying part of load at this power level.

*Note: It is possible that these heat pipe I.D. numbers are the reverse of those used by TRW. This confusion resulted from the identification numbers not being inscribed on the heat pipes themselves and the fact that these two heat pipes are identical in external appearance. The results shown in this table seem to verify this apparent reversal.

TABLE 7.6 Heat Transport Capacity of SEP Heat Pipes (Arteries Deprimed)

Module Configuration	Heat Pipe Number	Heat Transport Capacity (Watts) At Max. Evap. Temp. of 150°F
A	1,2,4	85
B	3,5,7	110

FIGURE 7.1 Temperature Profile Prior to Heat Pipe Number 4 Depriming

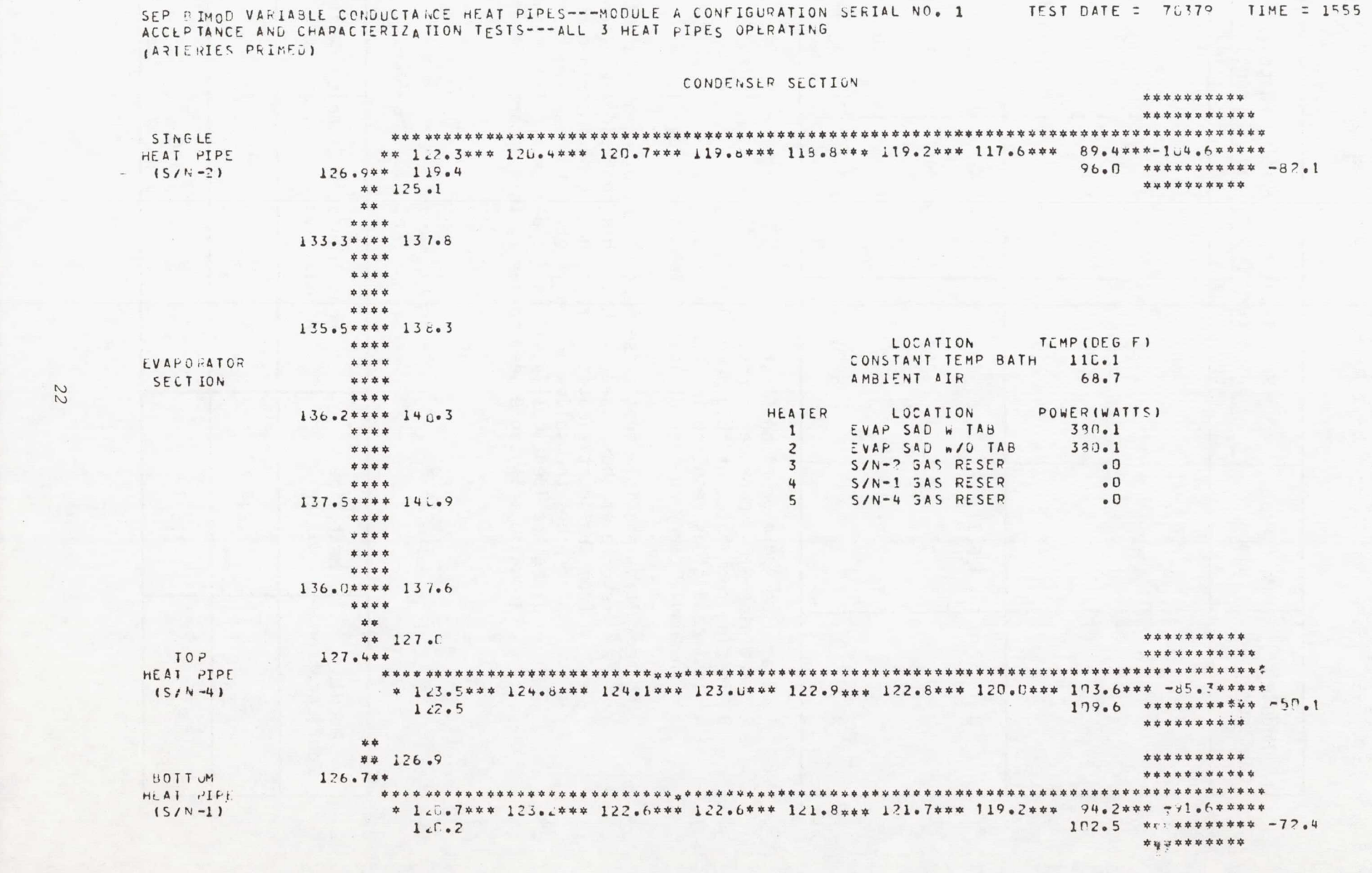


FIGURE 7.2 Temperature Profile After Heat Pipe Number 4 Depriming

FIGURE 7.3 Temperature Profile Prior to Heat Pipe Number 2 Depriming

FIGURE 7.4 Temperature Profile After Heat Pipe Number 2 Depriming

FIGURE 7.5 Temperature Profile Prior to Heat Pipe Number 3 Depriming, With Evaporator Heater Power Just Below Deprime Level

FIGURE 7.6 Temperature Profile Prior to Heat Pipe Number 3 Depriming, With Evaporator Heater Power Higher Than Deprime Level

FIGURE 7.7 Temperature Profile After Heat Pipe Number 3 Depriming

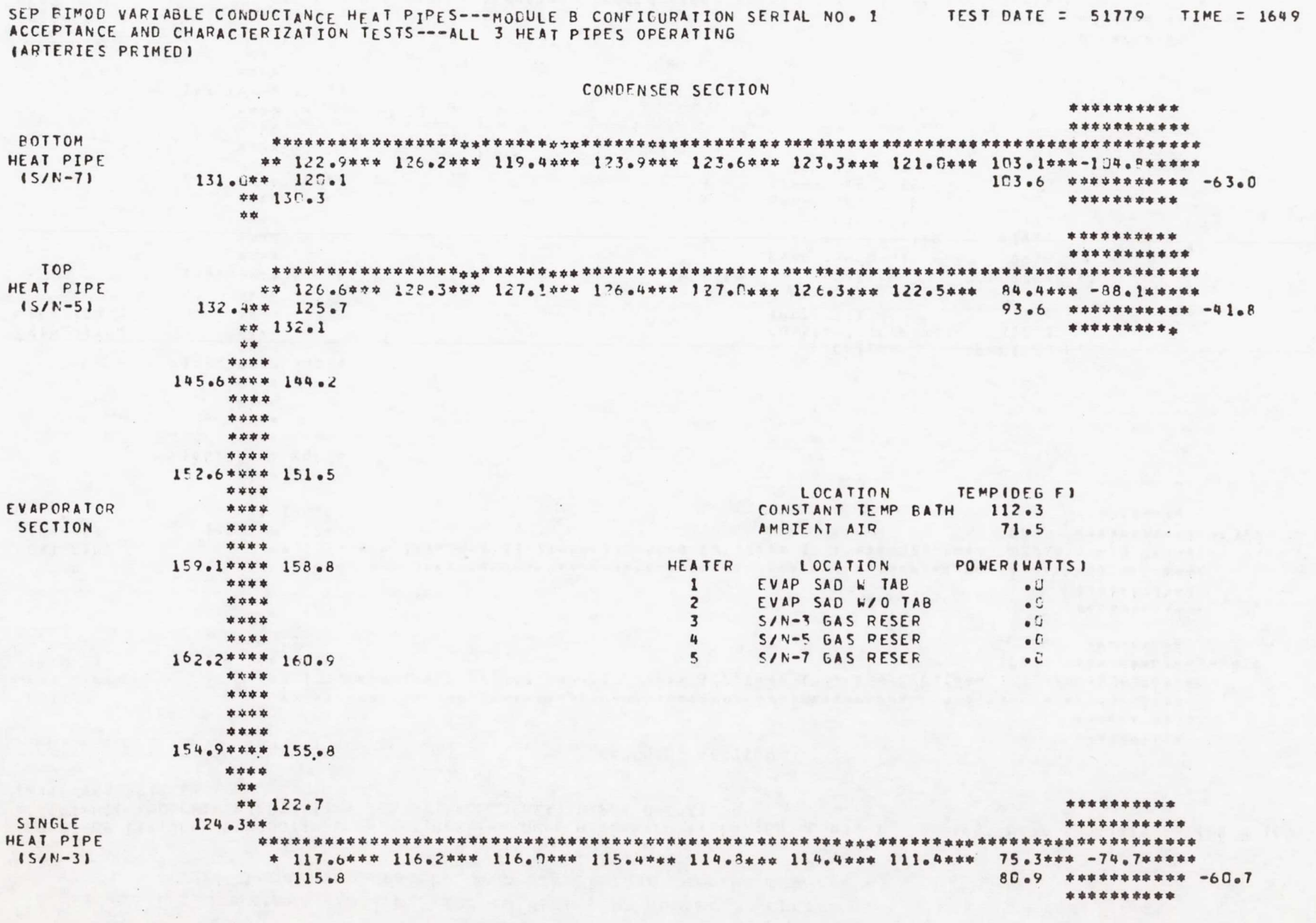


FIGURE 7.8 Temperature Profile With Power to Evaporator Heater Number 1 Only

FIGURE 7.9 Temperature Profile With Power to Evaporator Heater Number 2 Only

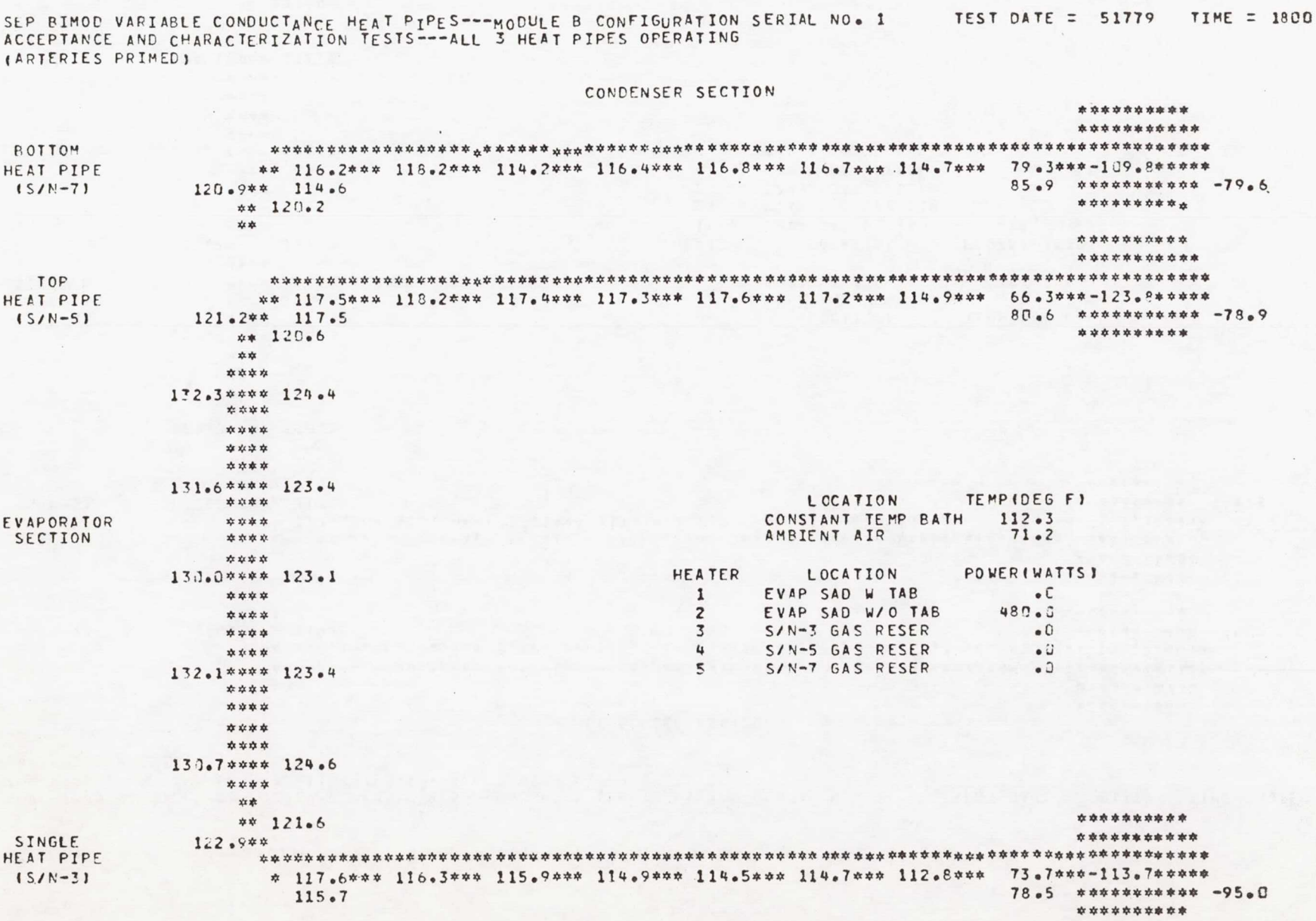


FIGURE 7.10 Temperature Profile With Power to Evaporator Heater Number 1 Only

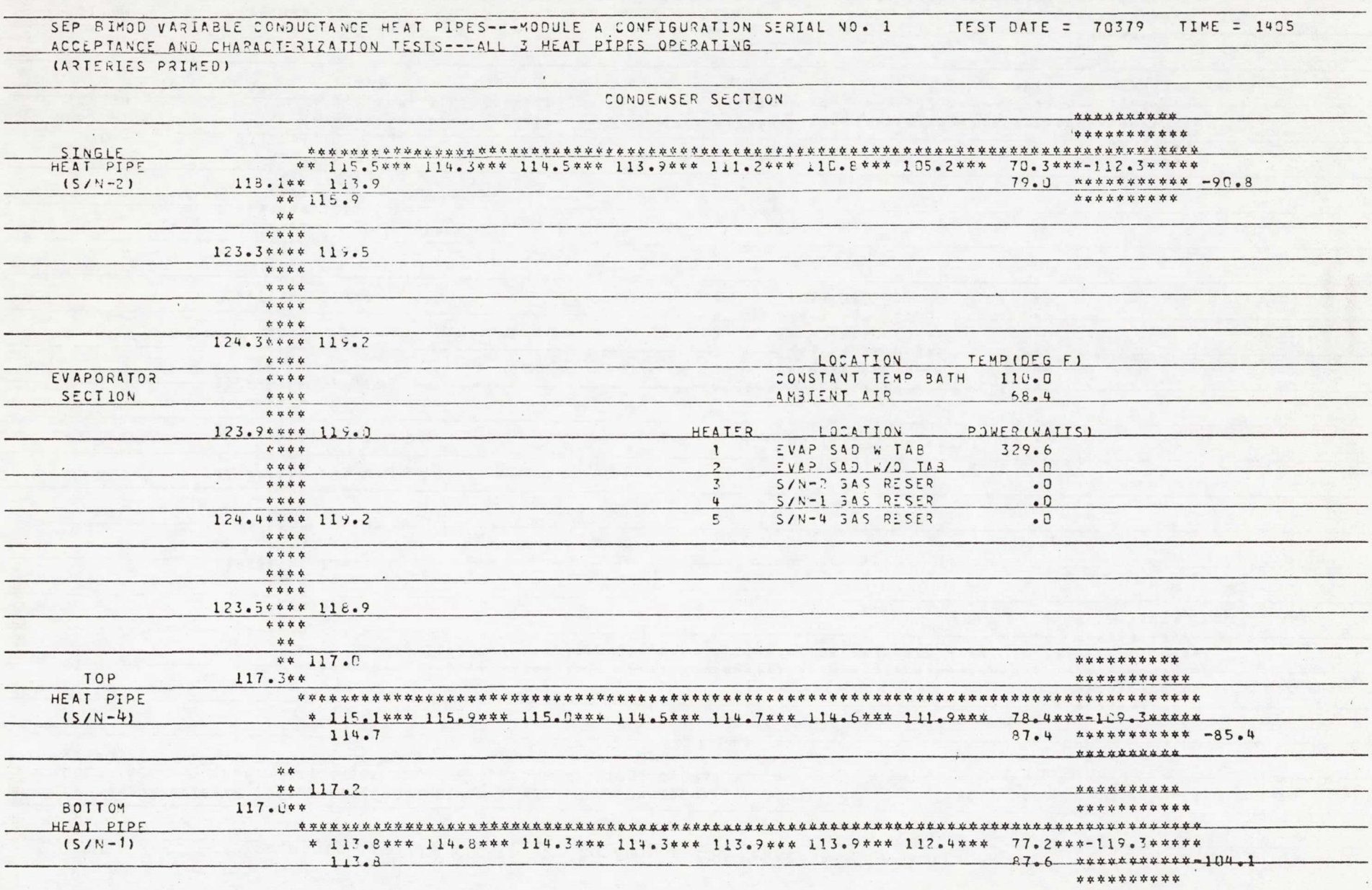


FIGURE 7.11 Temperature Profile With Power to Evaporator Heater Number 2 Only

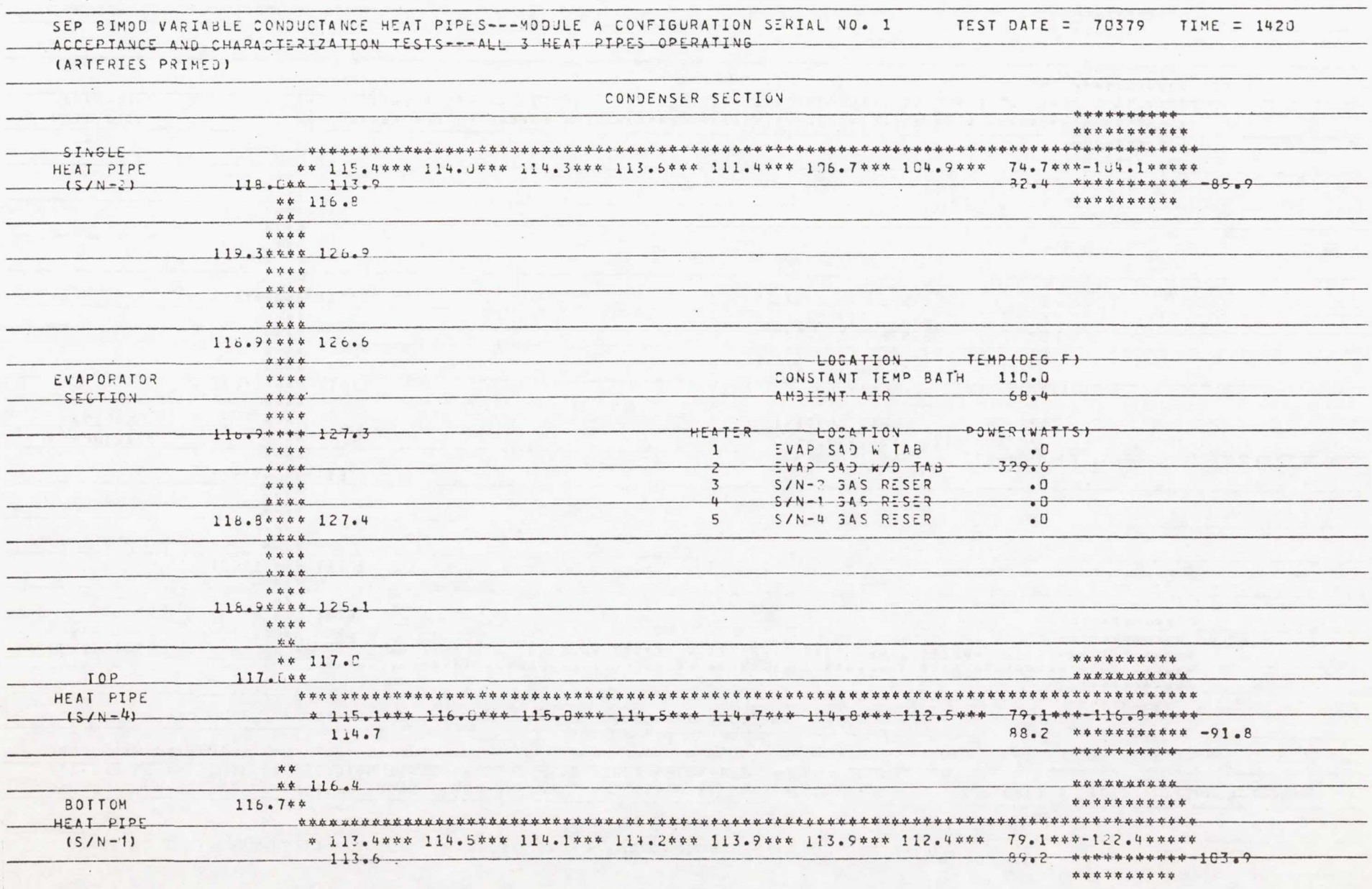
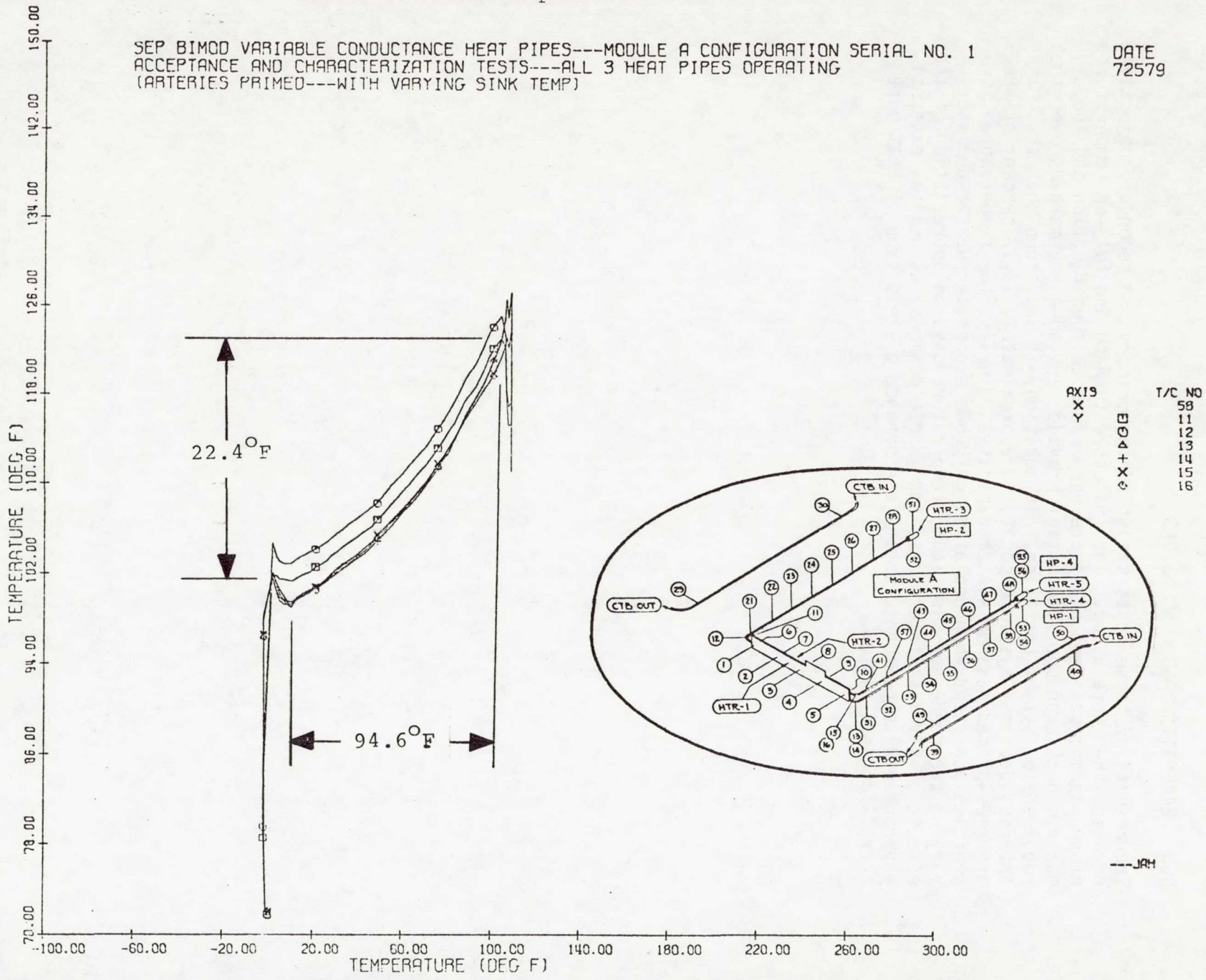


FIGURE 7.12 Constant Temperature Bath Fluid Temperature-vs-Heat Pipe Adiabatic Section Temperatures



8.0 EVALUATION AND CONCLUSIONS

The results of these tests satisfied the primary and secondary objectives on which they were based. The indicated turn-on and full-on temperatures of the individual heat pipes are very close to specification and the maximum heat transport capacities provide very adequate margins over that required for system operation. In addition, it was shown that the arteries-deprimed system capacity is approximately 11-12 percent of the arteries-primed maximum system capacity. Finally, the temperature profiles generated when operating only one evaporator heater and when varying the condenser sink (CTB) temperature gave an appreciation of the effects of RTV interface joints and saddle designs, as well as external environmental conditions, on the performance of this type of heat pipe thermal control system.

9.0 REFERENCES

1. 30-Centimeter Ion Thrust Subsystem Design Manual. NASA TM-79191, 1979.

2. Antoniuk, D. and Luedke, E.E.: CTS-Type Variable Conductance Heat Pipes for SEP FM/PPU. (TRW; NASA Contract NAS 3-21130.) NASA CR-159550, 1979.

APPENDIX A
DETAILED TEMPERATURE AND HEATER POWER DATA

Five types of figures can be found in Appendix A. The first three are plots of:

(1) Temperature profiles along the heat pipes at up to fifteen (15) specific times during the test sequence. Where there was more than one thermocouple at a point along the heat pipe length (e.g., on the evaporator and adiabatic sections and on the gas reservoirs), the average temperature was plotted in these figures.

(2) Temperature histories. Thermocouple histories were grouped as indicated in the following table.

Thermocouple Numbers	Location
1-10	Evaporator temperatures
11-16	Adiabatic section temperatures
21-30	First heat pipe condenser and cooling tube temps
31-40	Second heat pipe condenser and cooling tube temps
41,57,43-50	Third heat pipe condenser and cooling tube temps
51-56	Gas reservoir temperatures
58,59	Constant temperature bath (CTB) temperature and ambient air temperature

(3) Power histories of the two evaporator heaters (numbers 1 and 2) and the three gas reservoir heaters (numbers 3, 4, 5).

The last two types are instantaneous temperature-profile schematics which show the system reponse at the times of:

(4) Individual heat pipe turn-on condition (when thermocouple 21, 31, or 41 are within 5°F of the adiabatic section temperatures), and,

(5) Individual heat pipe or system full-on condition (equilibrium condition with 220 watts/heat pipe applied to evaporator heaters).

The sequence in which the data is presented is shown in the following table:

1979 Test Date	Run No.	Module Config.	Heat Pipes Oper.	Test Conditions: Arteries	Figure Type: First Figure of Given Type				
					1	2	3	4	5
5-17	1	B	3,5,7	Primed	A-1.1	A-1.3	A-1.10	A-1.11	A-1.14
5-21	1		3	Primed	A-2.1	A-2.3	A-2.10	A-2.11	A-2.12
5-29	1		5	Primed	A-3.1	A-3.3	A-3.10	A-3.11	A-3.12
5-30	1		7	Primed	A-4.1	A-4.3	A-4.10	A-4.11	A-4.12
5-31	1		3,5,7	Deprimed	A-5.1	A-5.3	A-5.10	A-5.11	A-5.14
7-3	1	A	2,1,4	Primed	A-6.1	A-6.3	A-6.10	A-6.11	A-6.14
7-19	1		2	Primed	A-7.1	A-7.3	A-7.10	A-7.11	A-7.12
7-23	1		1	Primed	A-8.1	A-8.3	A-8.10	A-8.11	A-8.12
7-24	1		4	Primed	A-9.1	A-9.5	A-9.12	A-9.13	A-9.14
	2		2,1,4	Deprimed	A-9.3	A-9.5	A-9.12	A-9.13	A-9.16
7-25	1		2,1,4	Primed [1]	A-10.1	A-10.5	A-10.12	A-10.13	---
	2		2,1,4	Primed [2]	A-10.3	A-10.5	A-10.12	---	A-10.15

[1] Varying sink temperature.

[2] Repeat of 7-3-79 test run.

FIGURE A-1.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

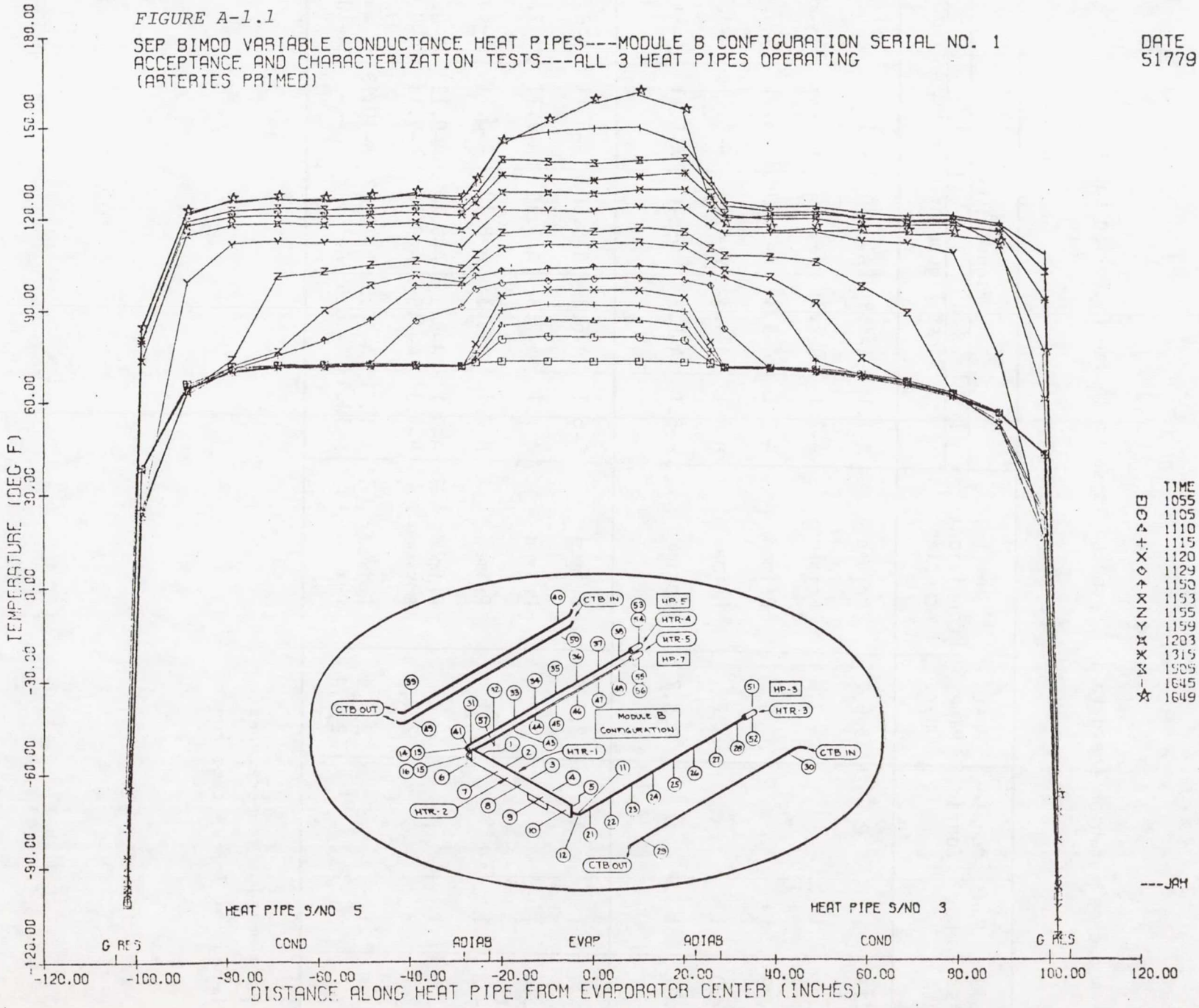


FIGURE A-1.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

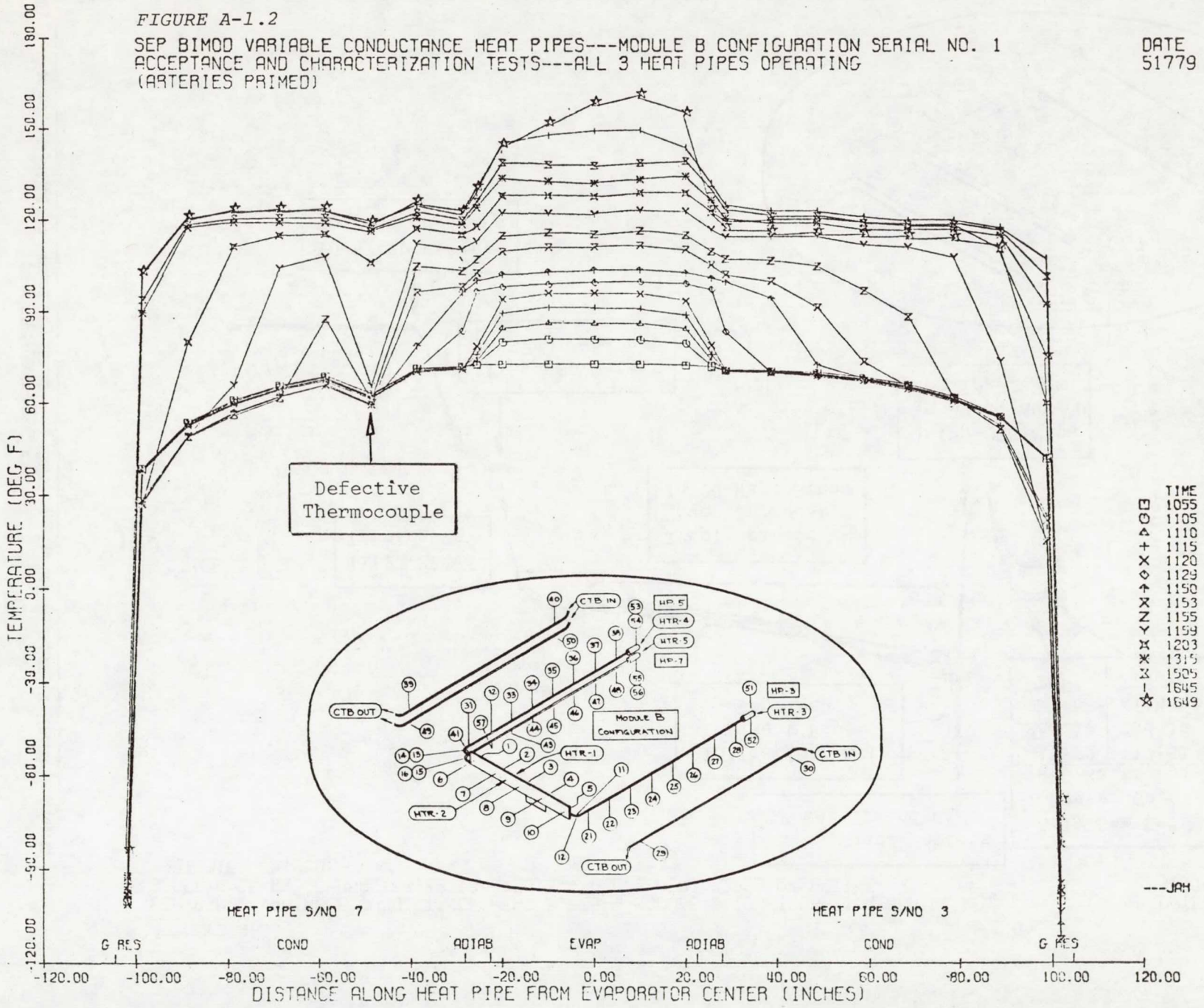


FIGURE A-1.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

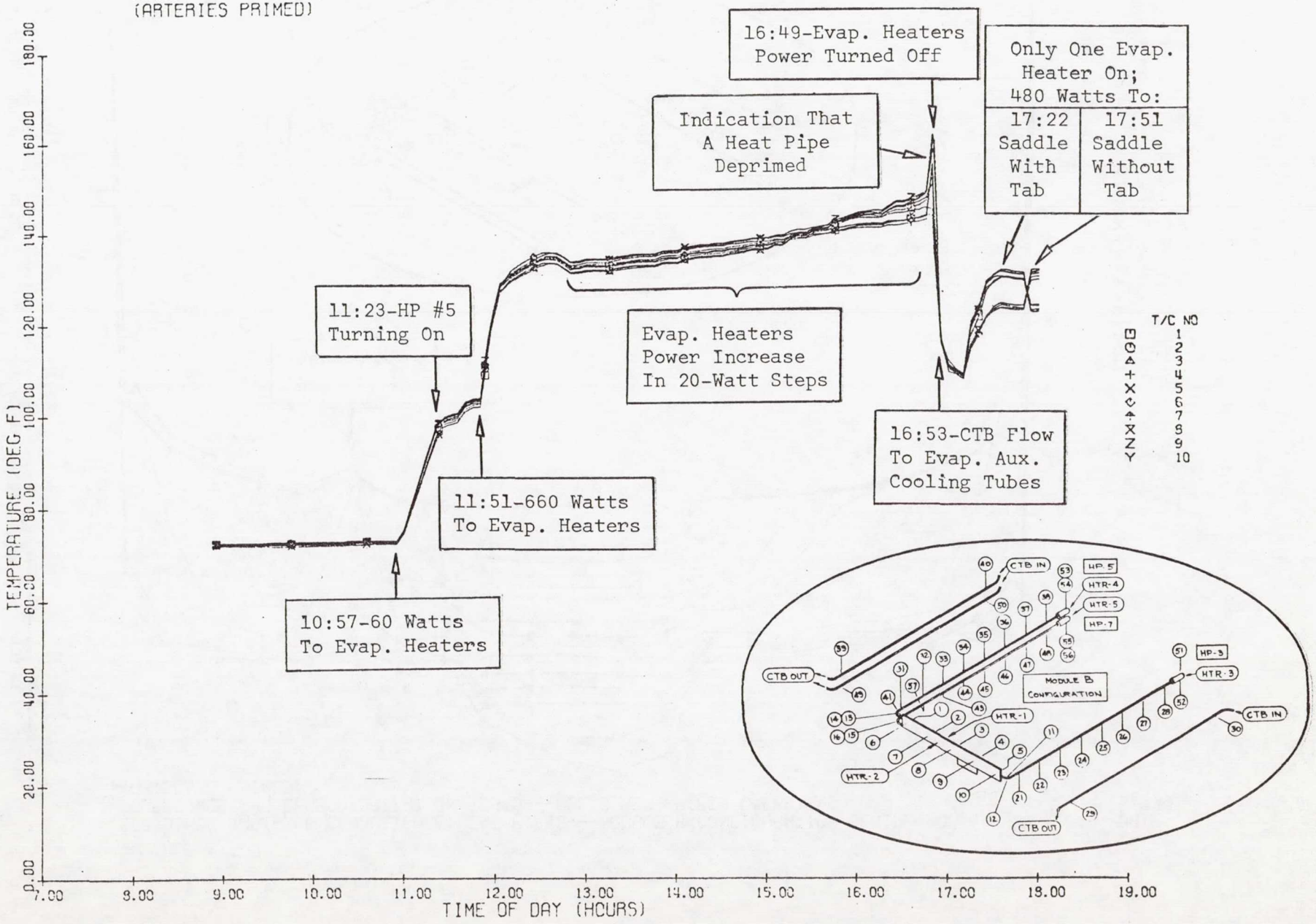


FIGURE A-1.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

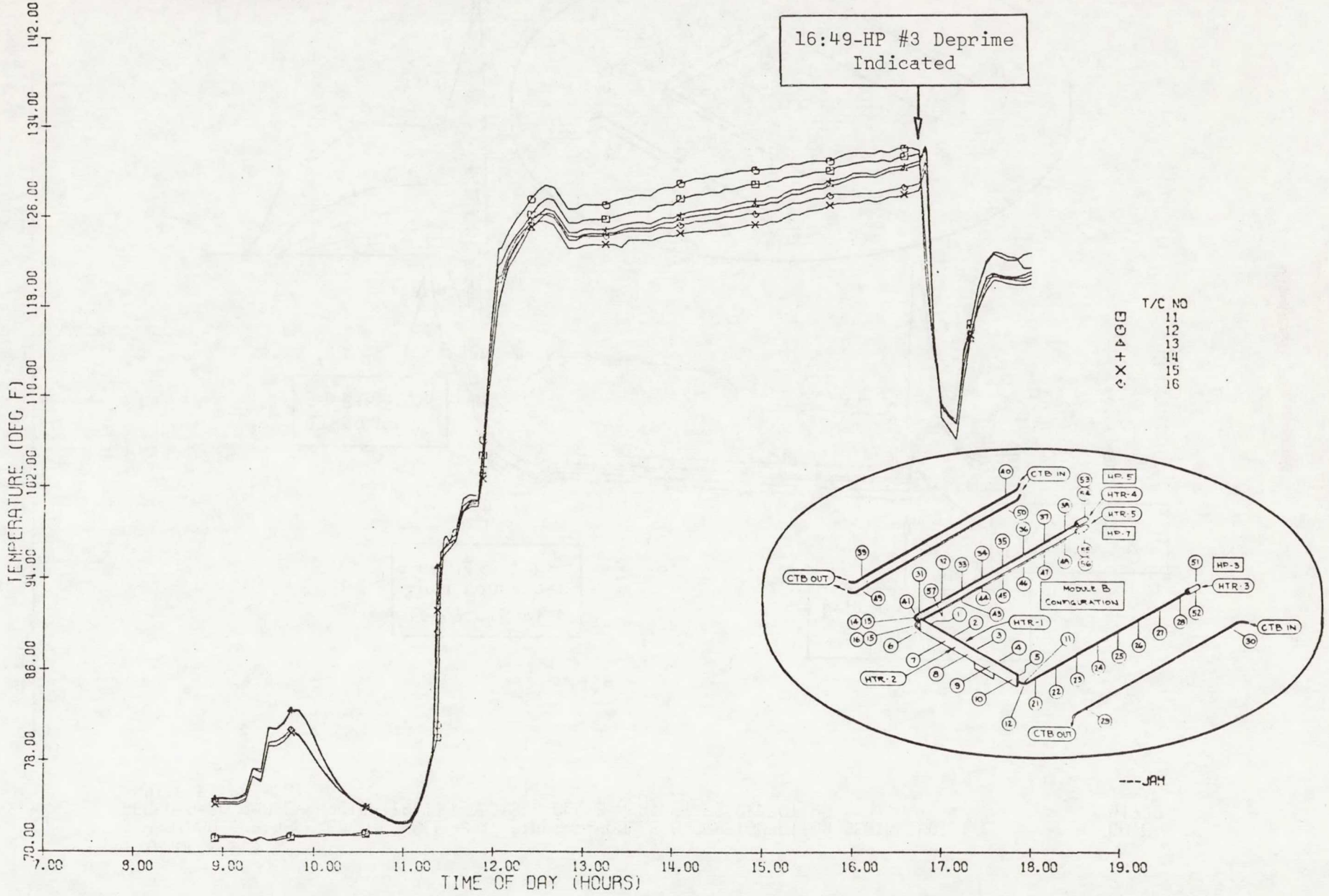


FIGURE A-1.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

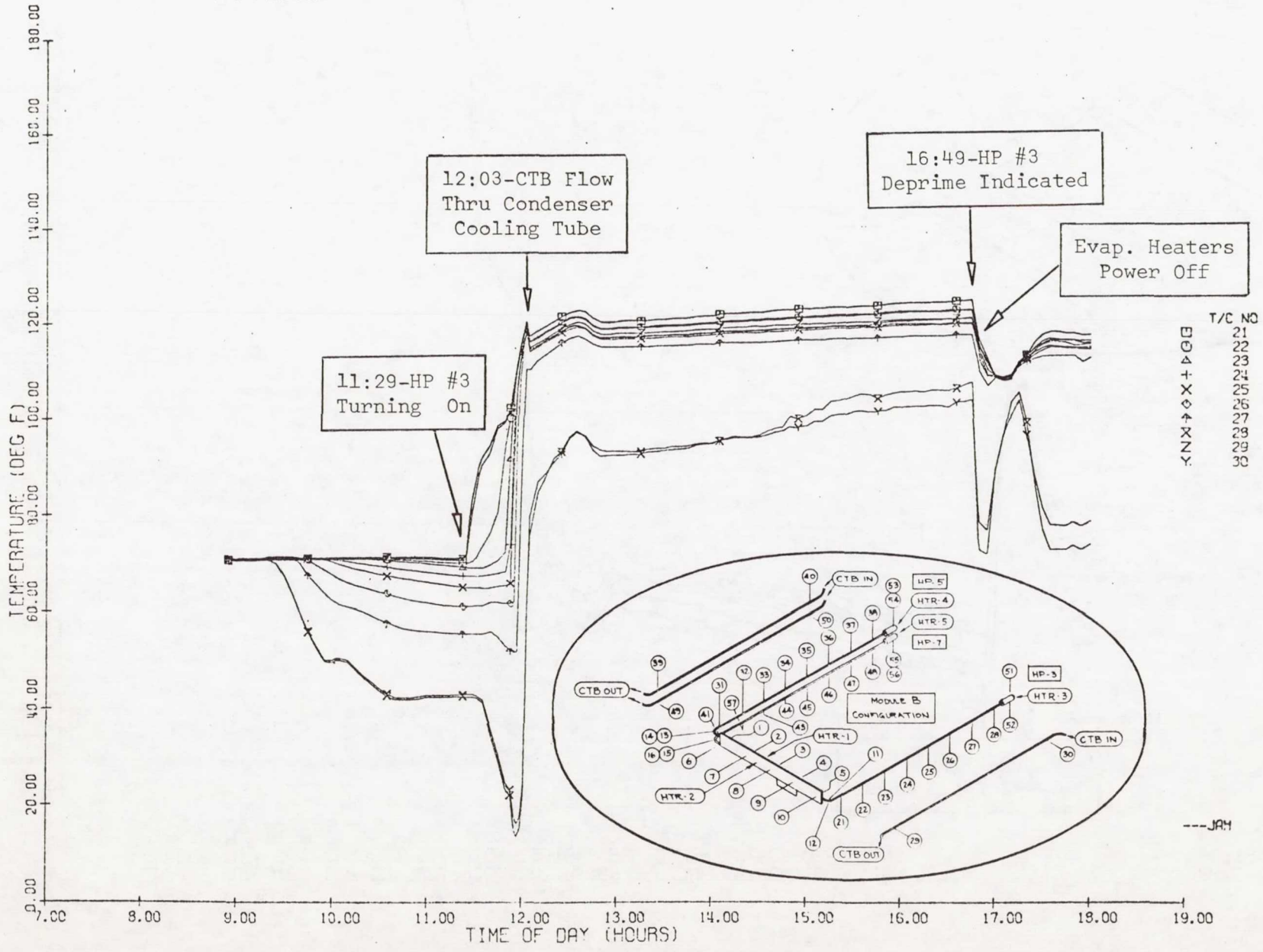


FIGURE A-1.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 DATE
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING 51779
(ARTERIES PRIMED)

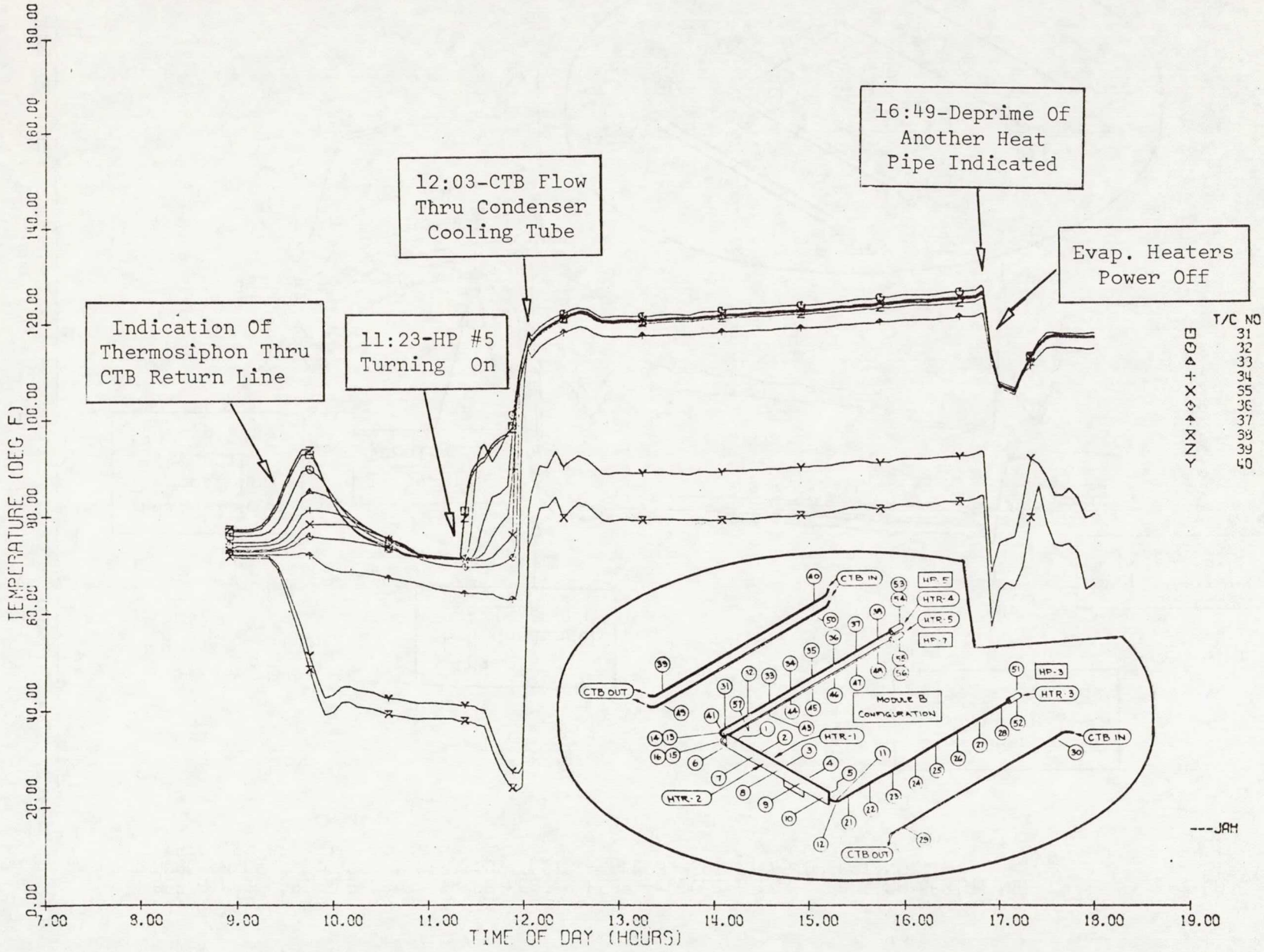


FIGURE A-1.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 DATE
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING 51779
(ARTERIES PRIMED)

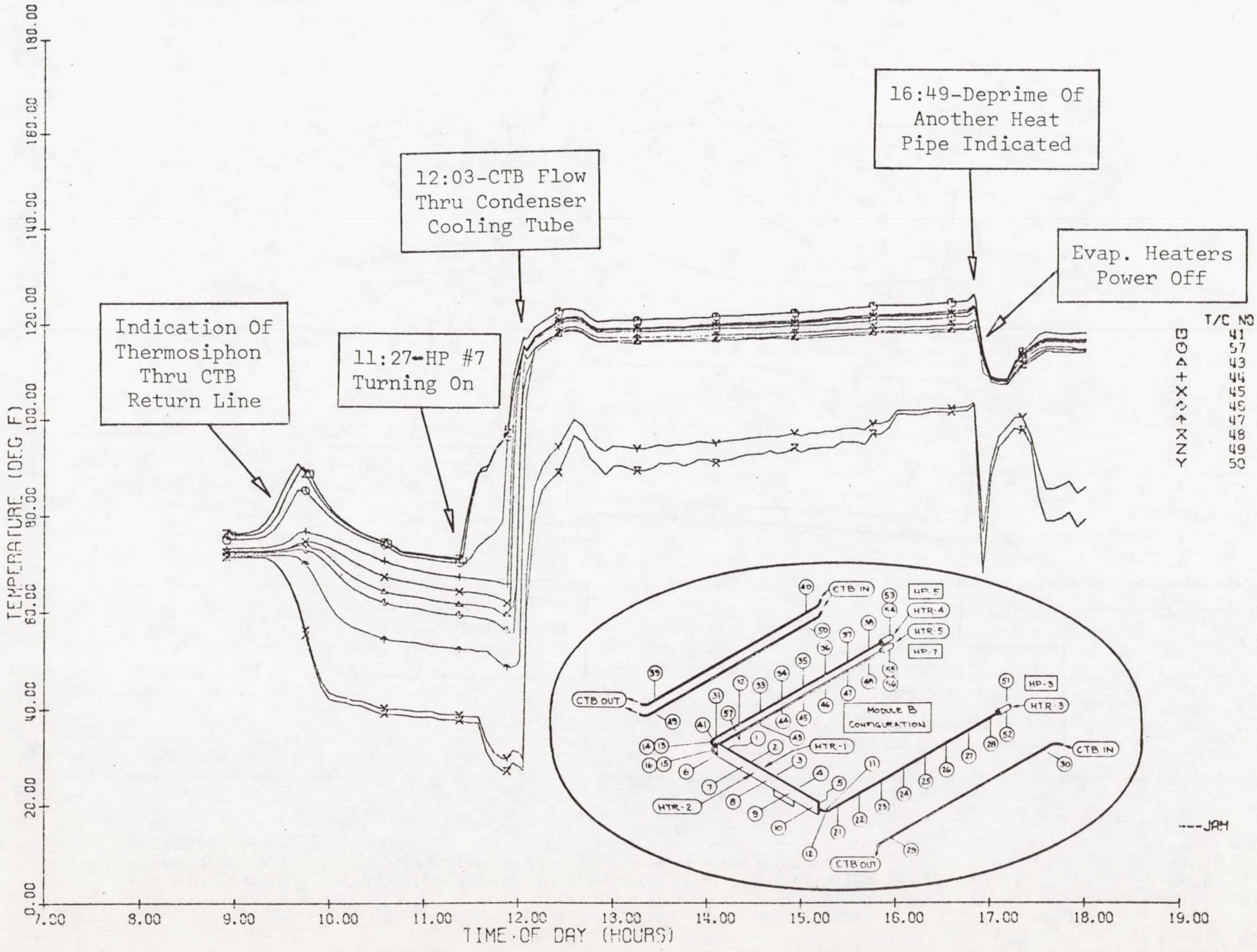
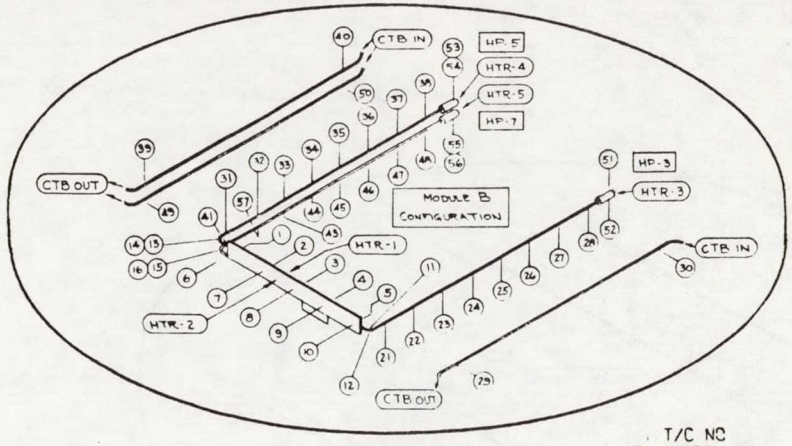


FIGURE A-1.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779



T/C NO
51
52
53
54
55
56

TEMPERATURE (DEG F)
160.00
120.00
80.00
40.00
0.00
-40.00
-80.00
-120.00
-160.00
-200.00

7.00 8.00 9.00 10.00 11.00 12.00 13.00 14.00 15.00 16.00 17.00 18.00 19.00

TIME OF DAY (HOURS)

---JAH

FIGURE A-1.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES----MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

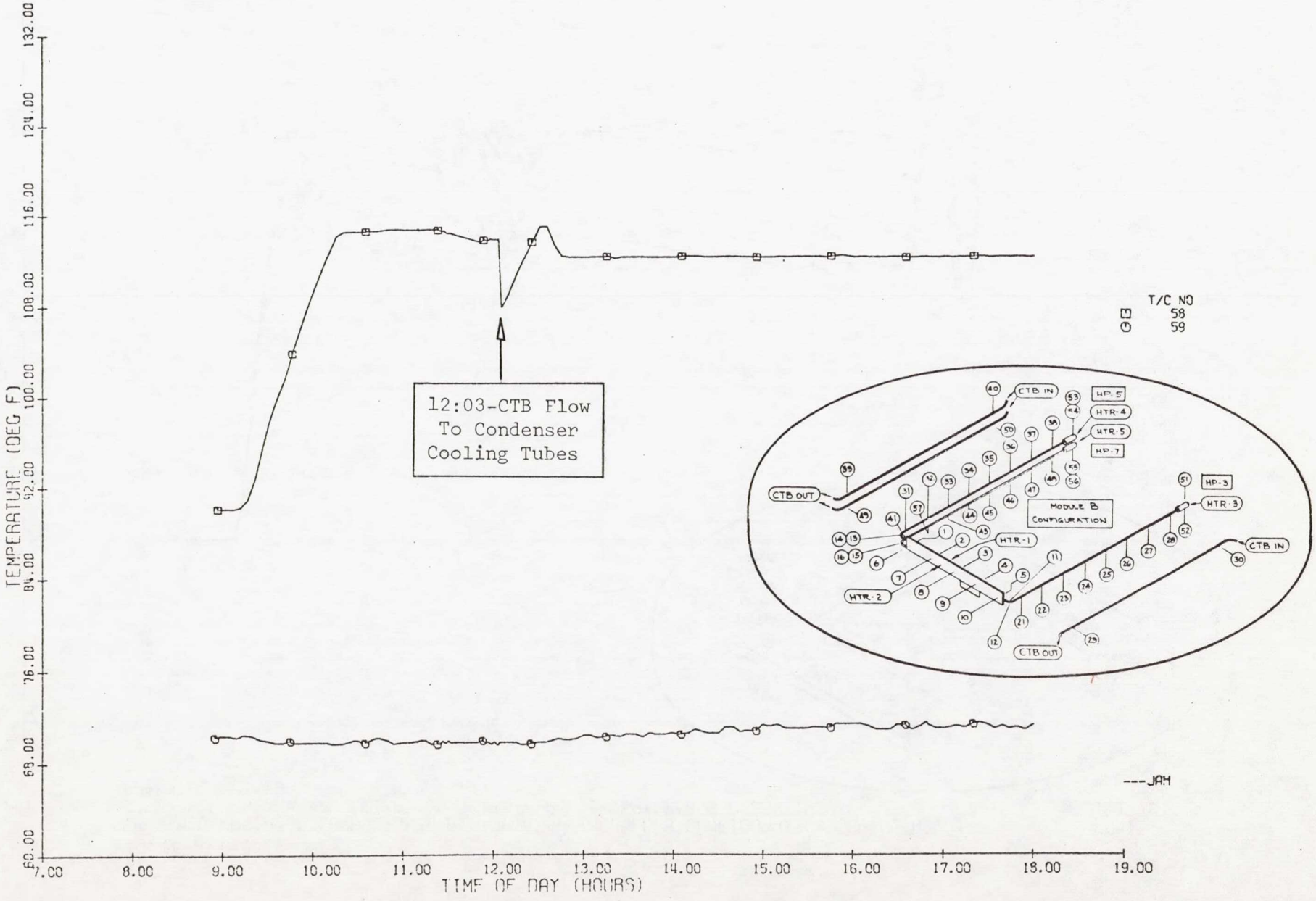


FIGURE A-1.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
51779

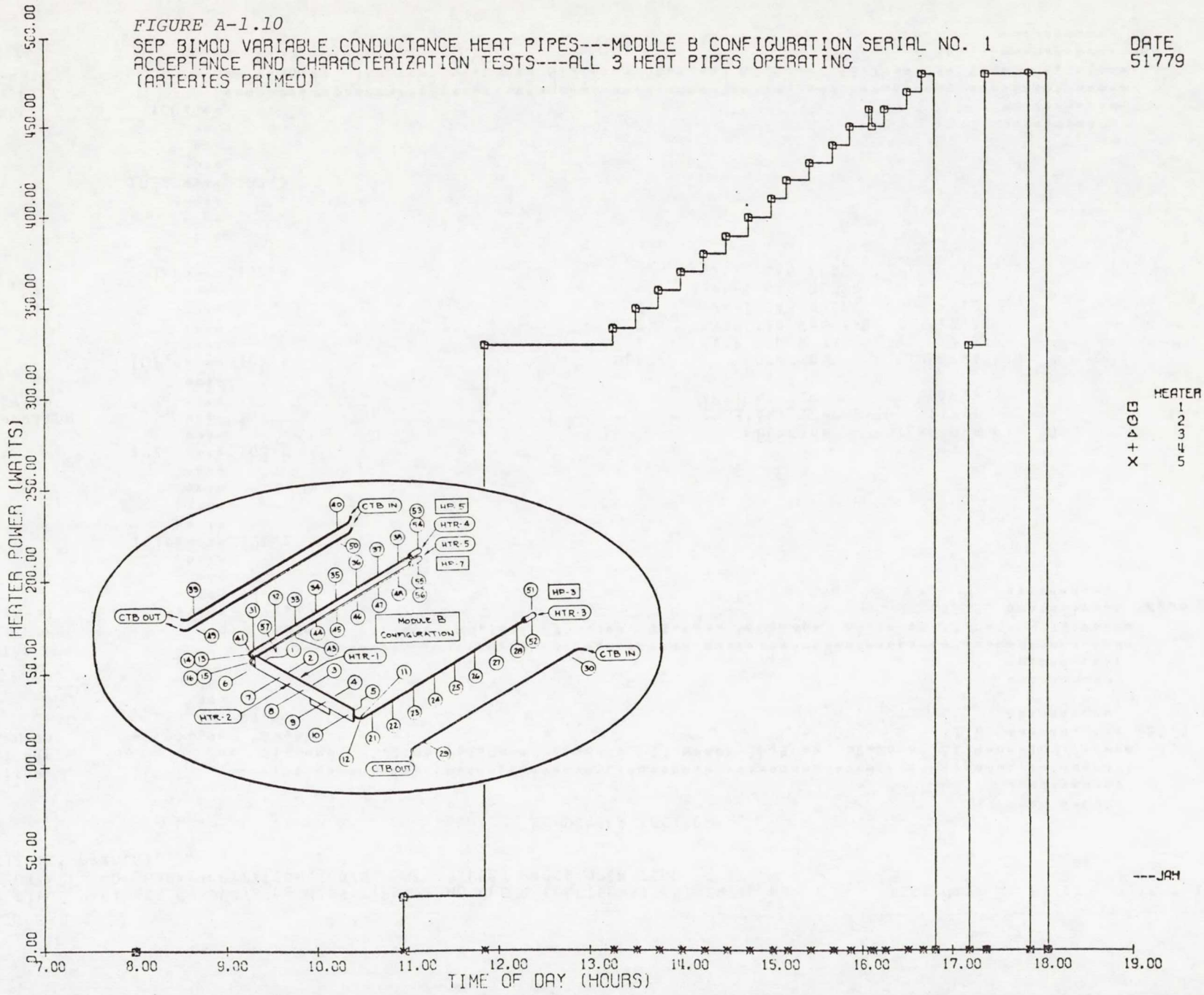
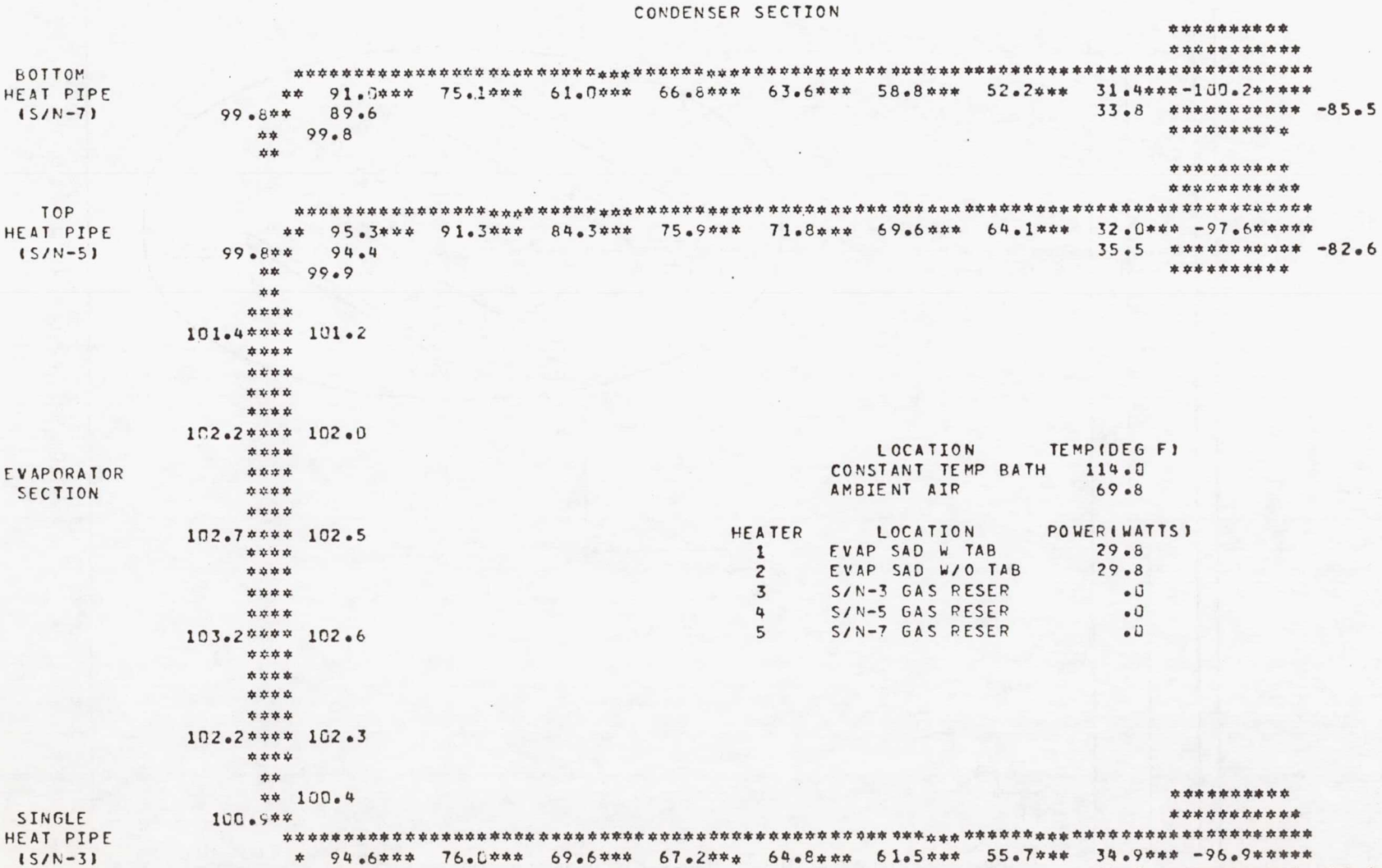


FIGURE A-1.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 51779 TIME = 1140
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)



LOCATION	TEMP (DEG F)
CONSTANT TEMP BATH	114.0
AMBIENT AIR	69.8

HEATER	LOCATION	POWER (WATTS)
1	EVAP SAD W TAB	29.8
2	EVAP SAD W/O TAB	29.8
3	S/N-3 GAS RESER	.0
4	S/N-5 GAS RESER	.0
5	S/N-7 GAS RESER	.0

FIGURE A-1.12

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 51779 TIME = 1145
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

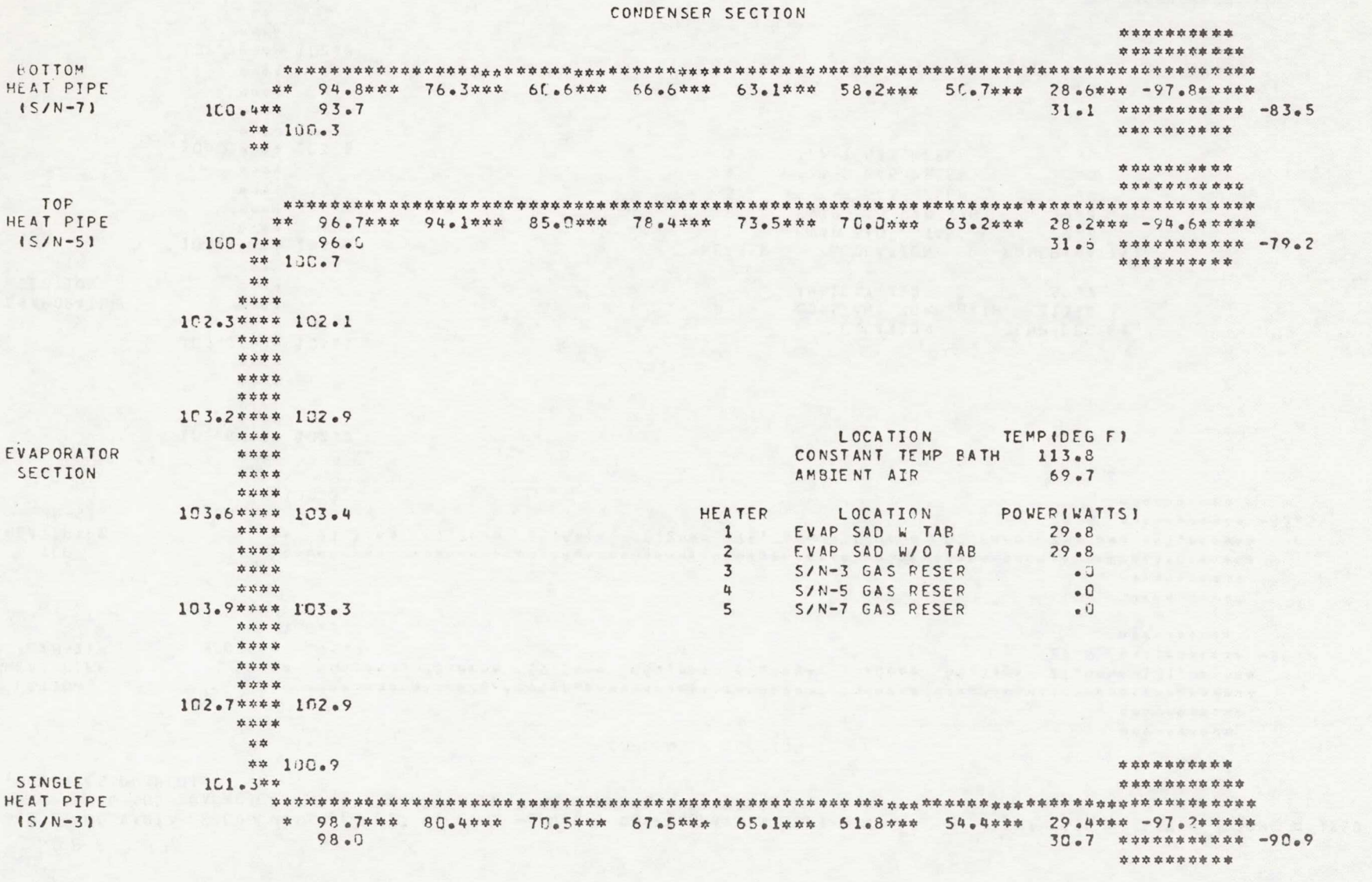


FIGURE A-1.13

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 51779 TIME = 1150
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

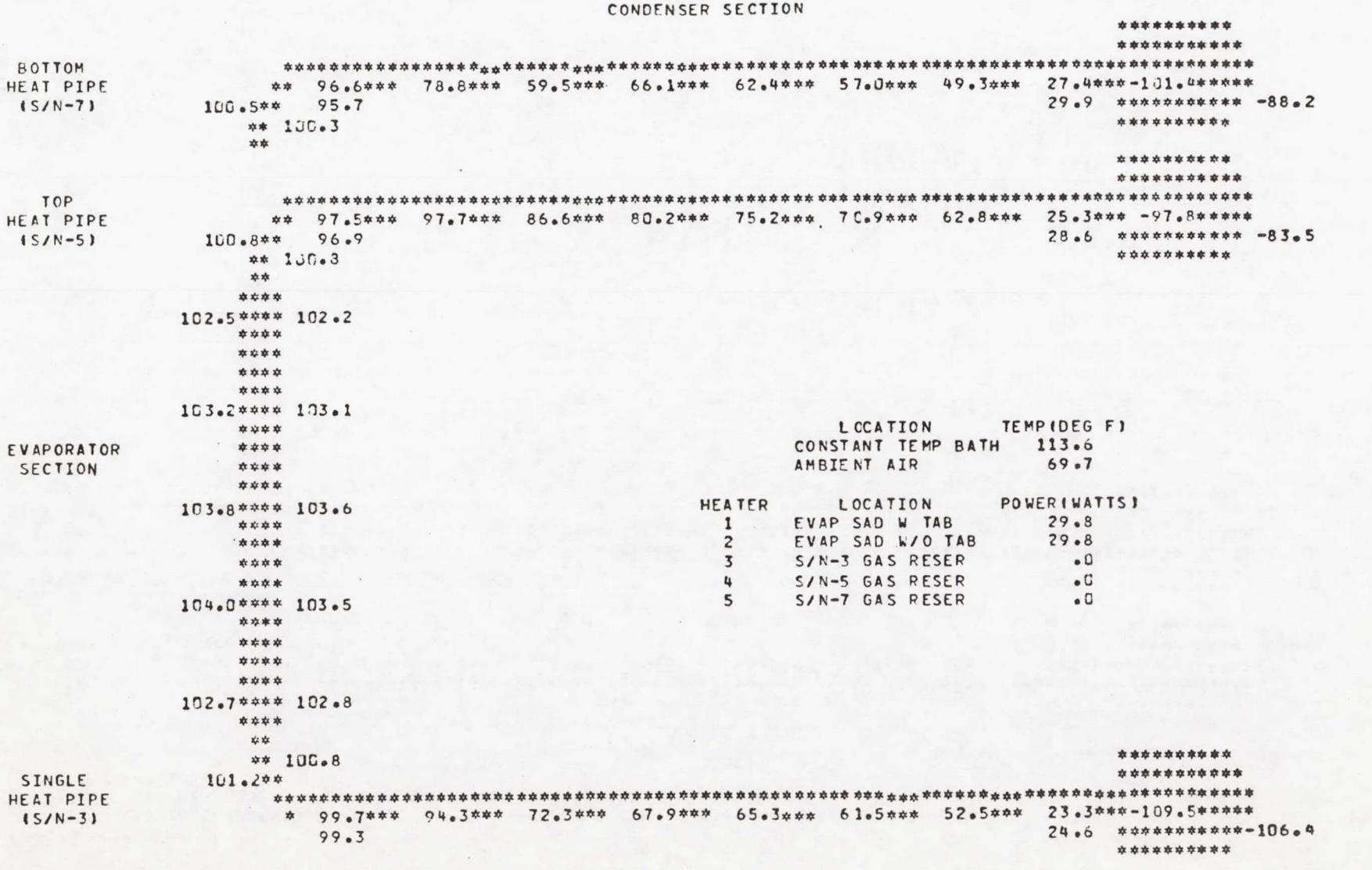


FIGURE A-1.14

SEP PIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 51779 TIME = 1300
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

FIGURE A-2.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

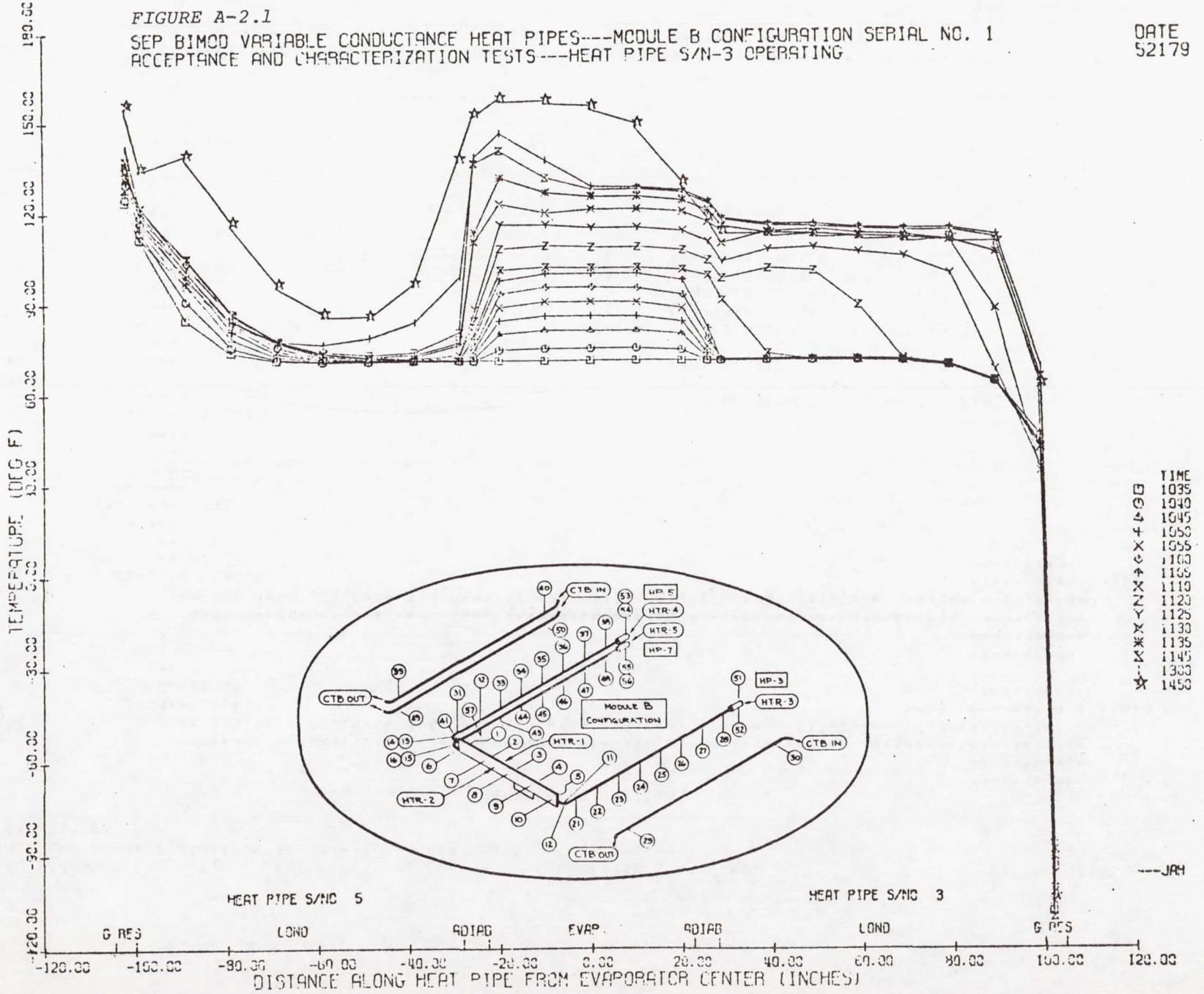


FIGURE A-2.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

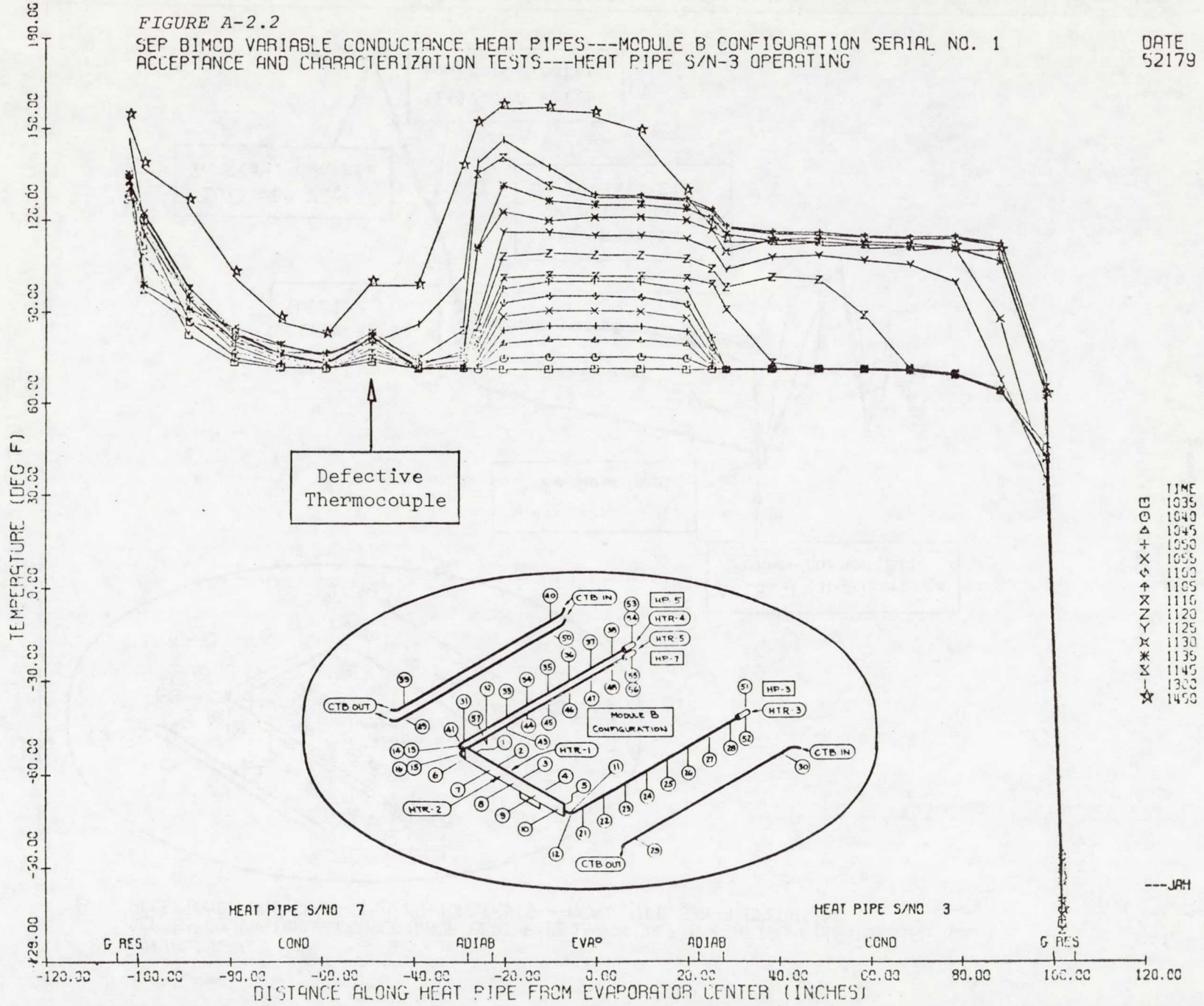


FIGURE A-2.3

SEP BIMCD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE 52179

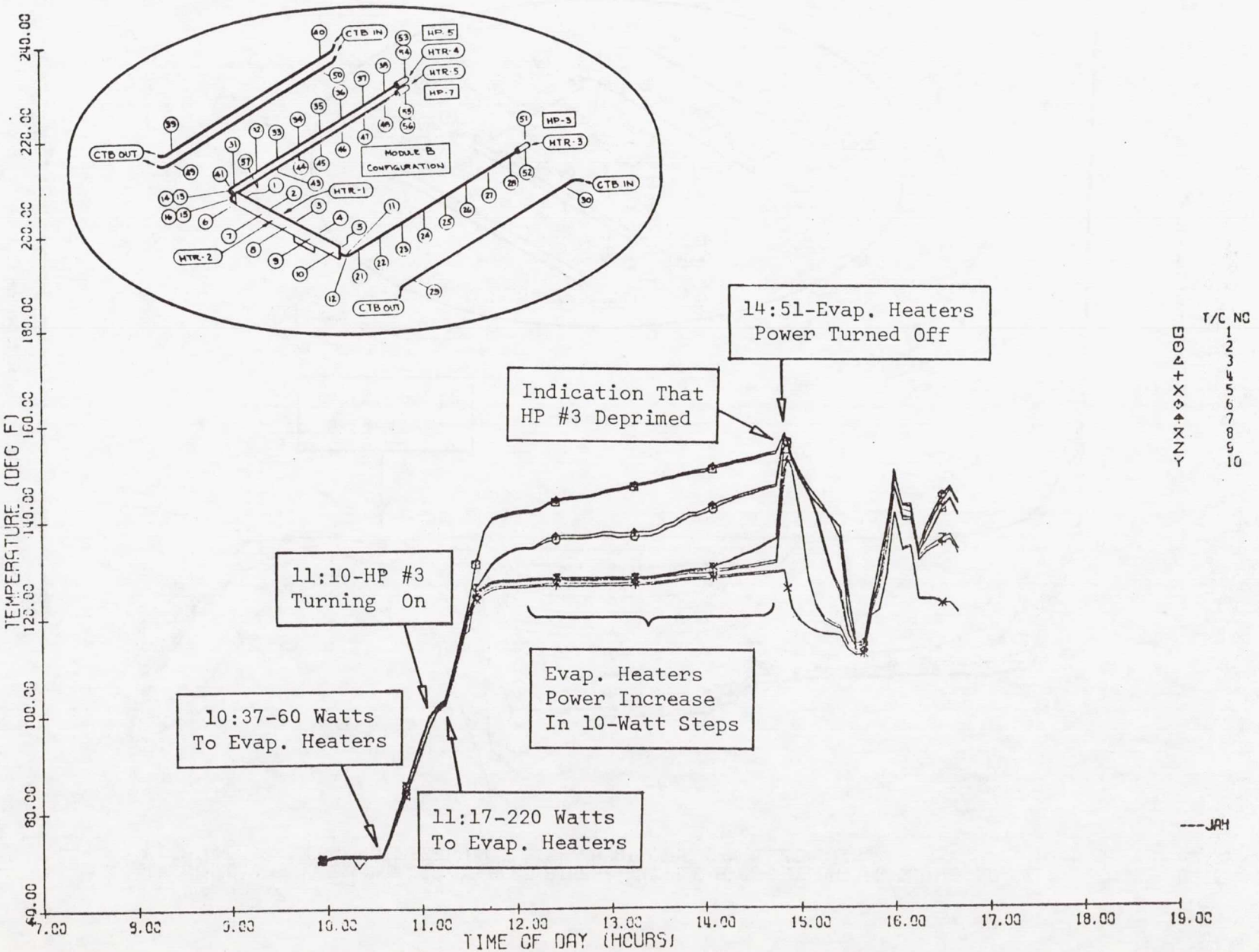


FIGURE A-2.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

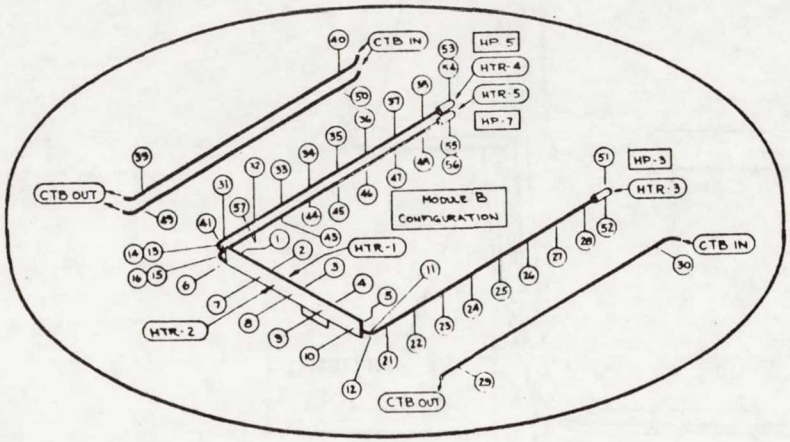


FIGURE A-2.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

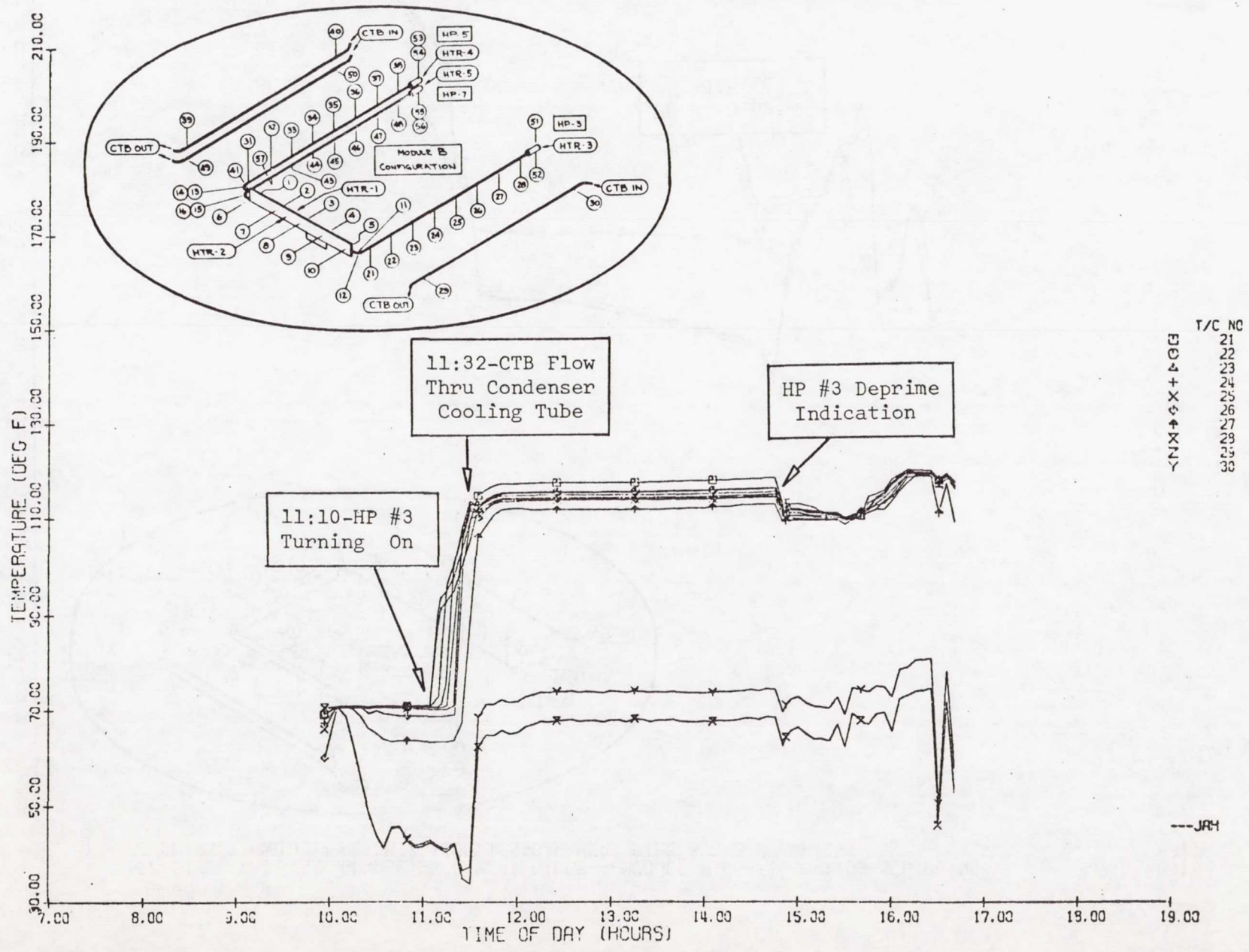


FIGURE A-2.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

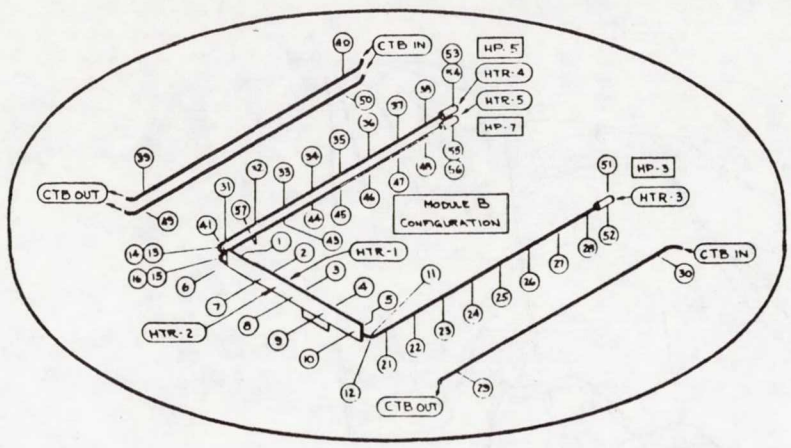


FIGURE A-2.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

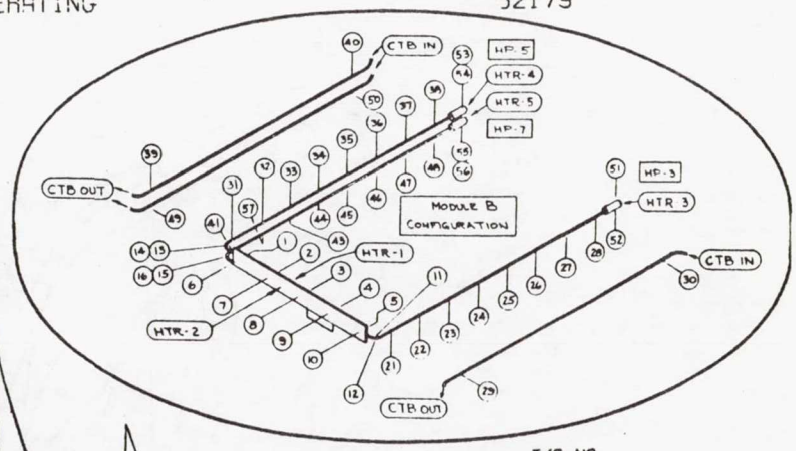


FIGURE A-2.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

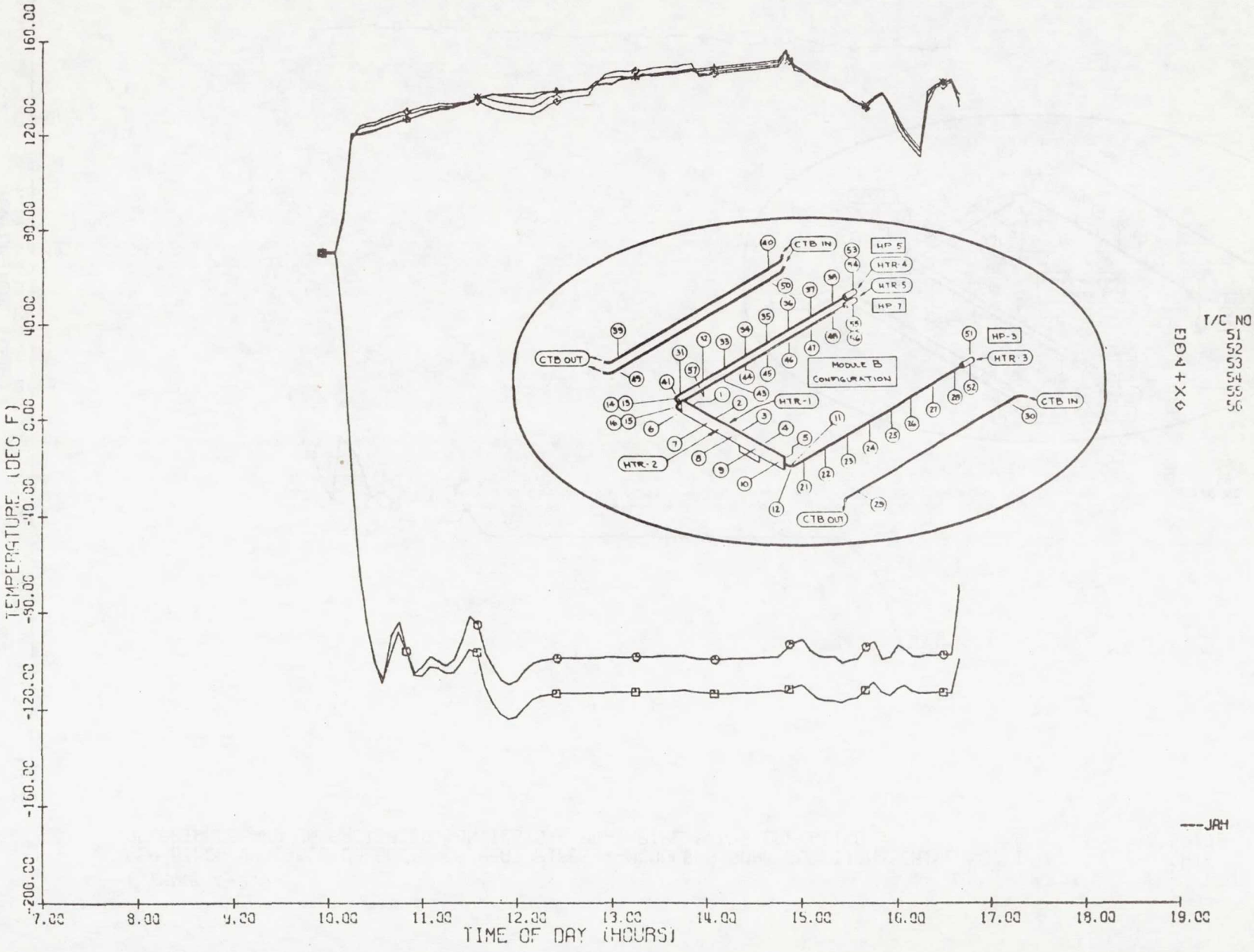


FIGURE A-2.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

DATE
52179

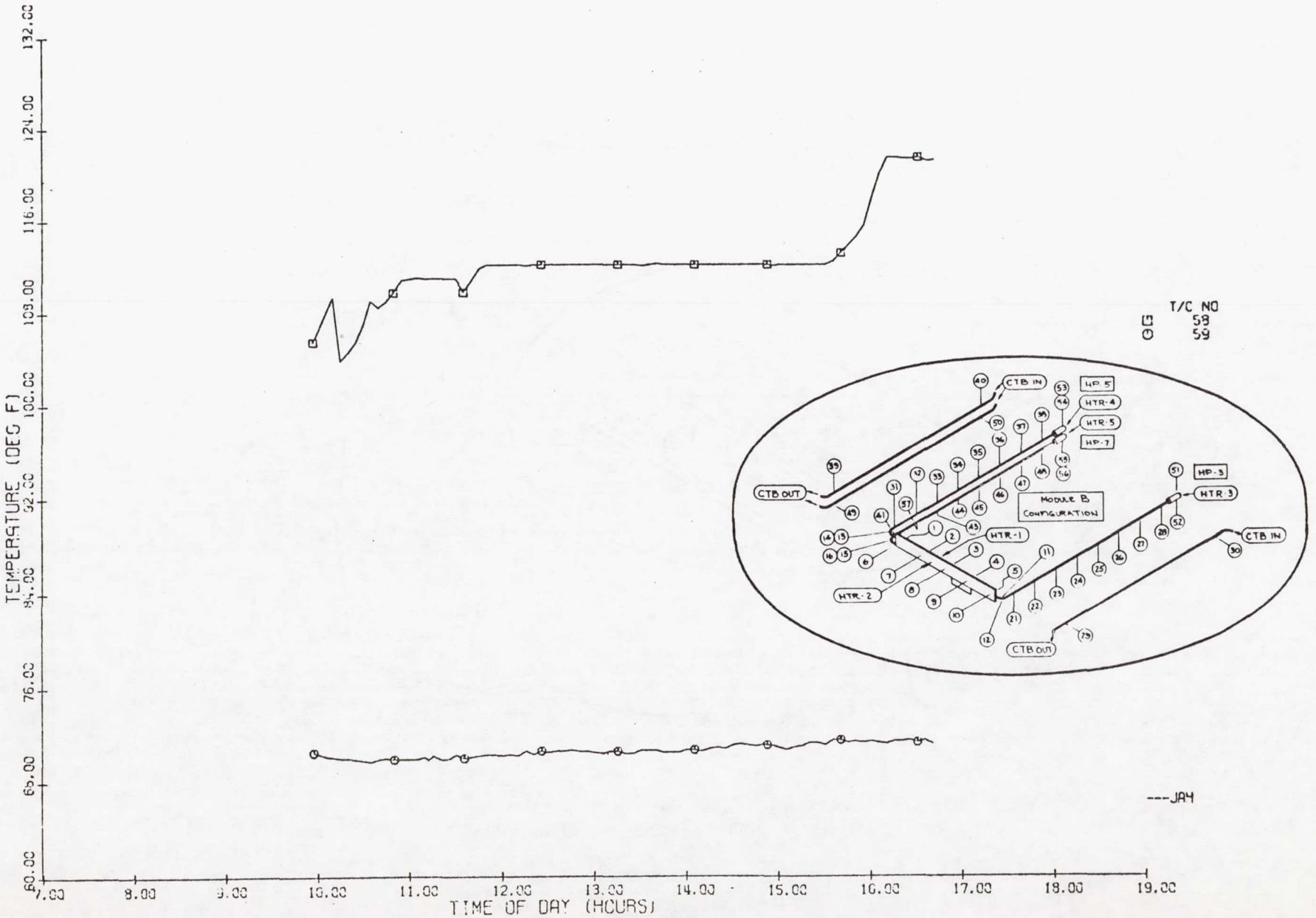


FIGURE A-2.10

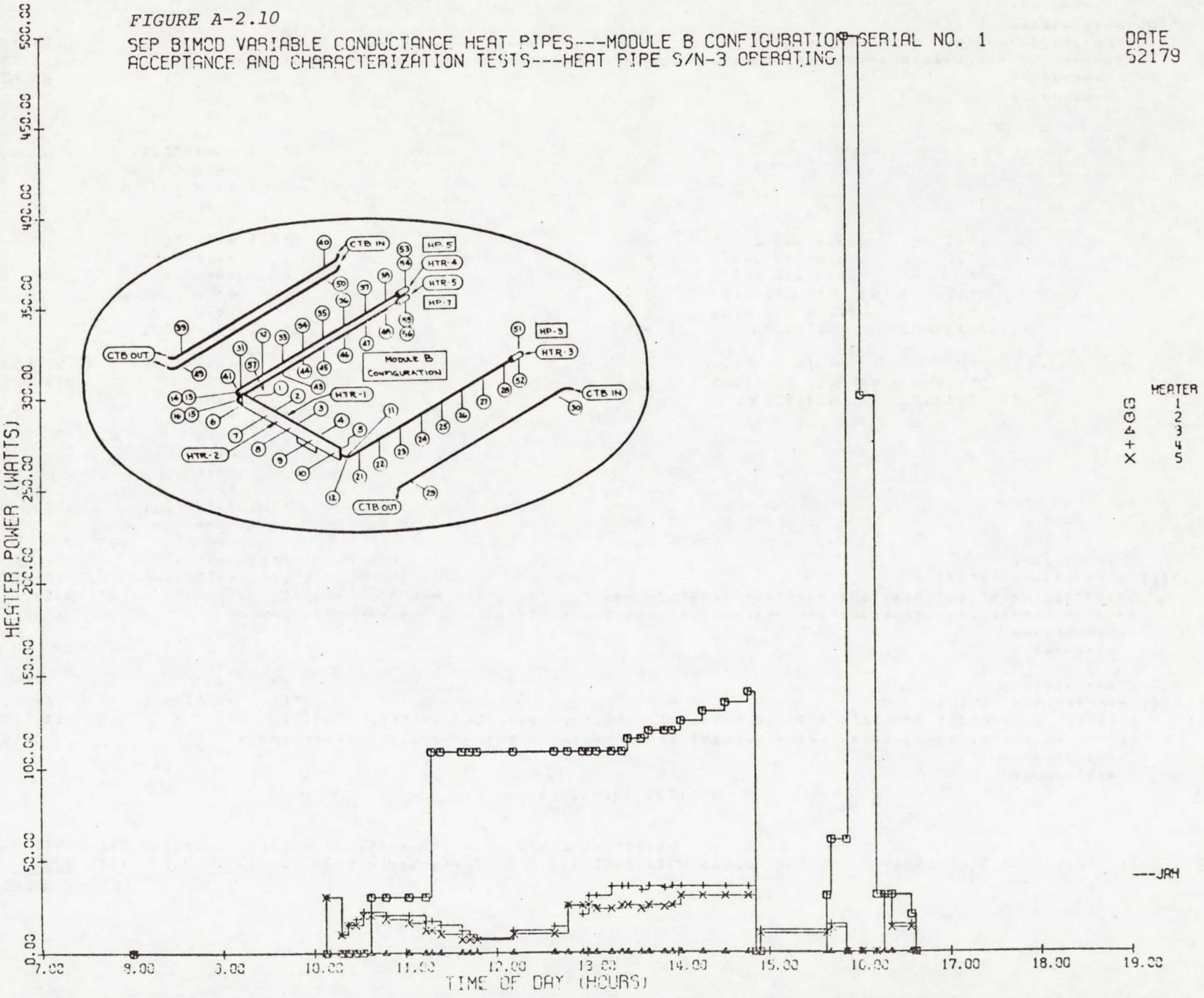

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING
DATE
52179
HEATER POWER (WATTS)
TIME OF DAY (HOURS)
HEATER
1
2
3
4
5
---JRH
CTB IN
CTB OUT
HTR-1
HTR-2
HTR-3
HTR-4
HTR-5
HP-3
HP-5
HP-7
MODULE B CONFIGURATION

FIGURE A-2.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 52179 TIME = 1115
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

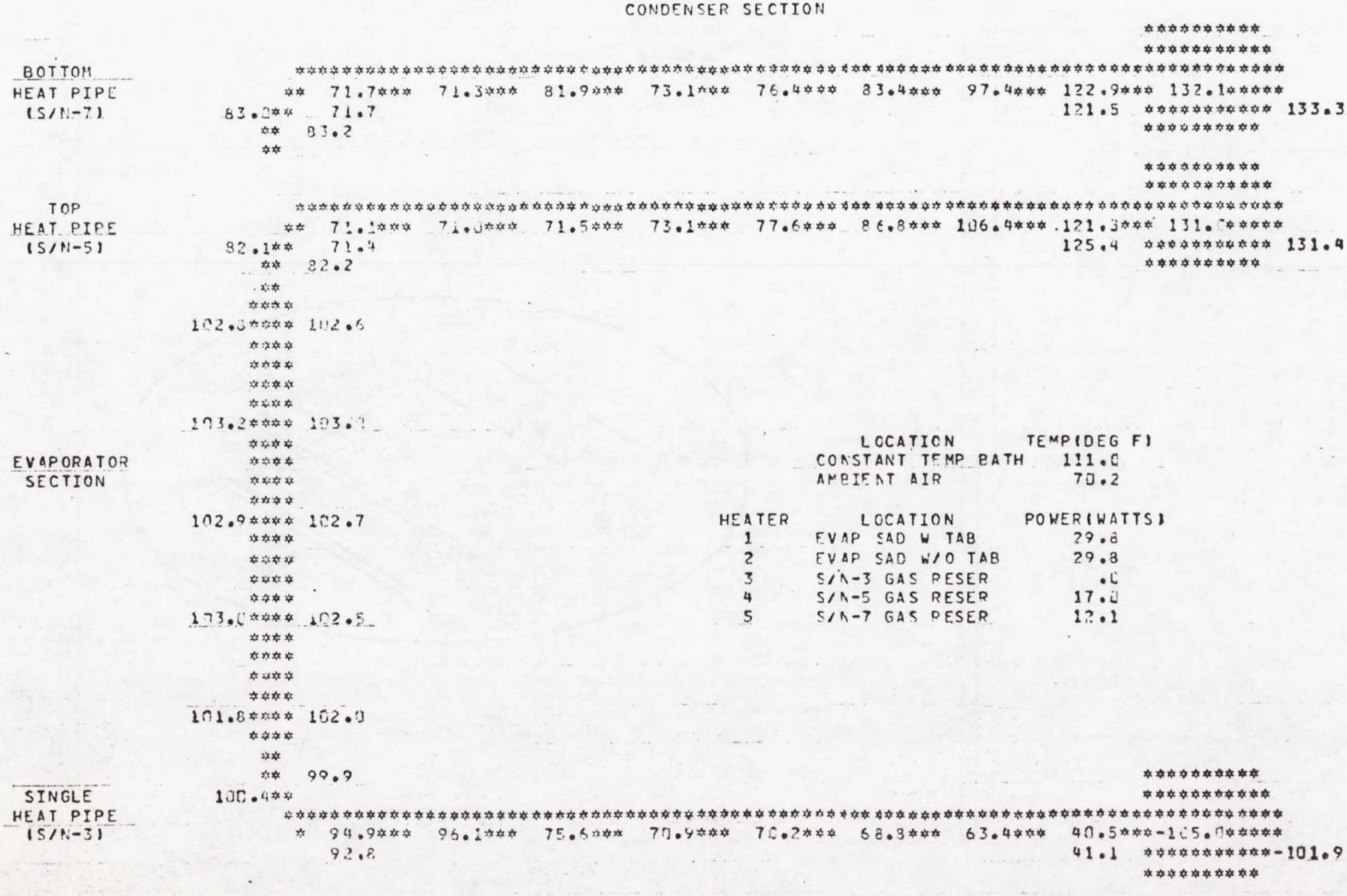


FIGURE A-2.12

SEP RIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 52179 TIME = 1315
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-3 OPERATING

FIGURE A-3.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

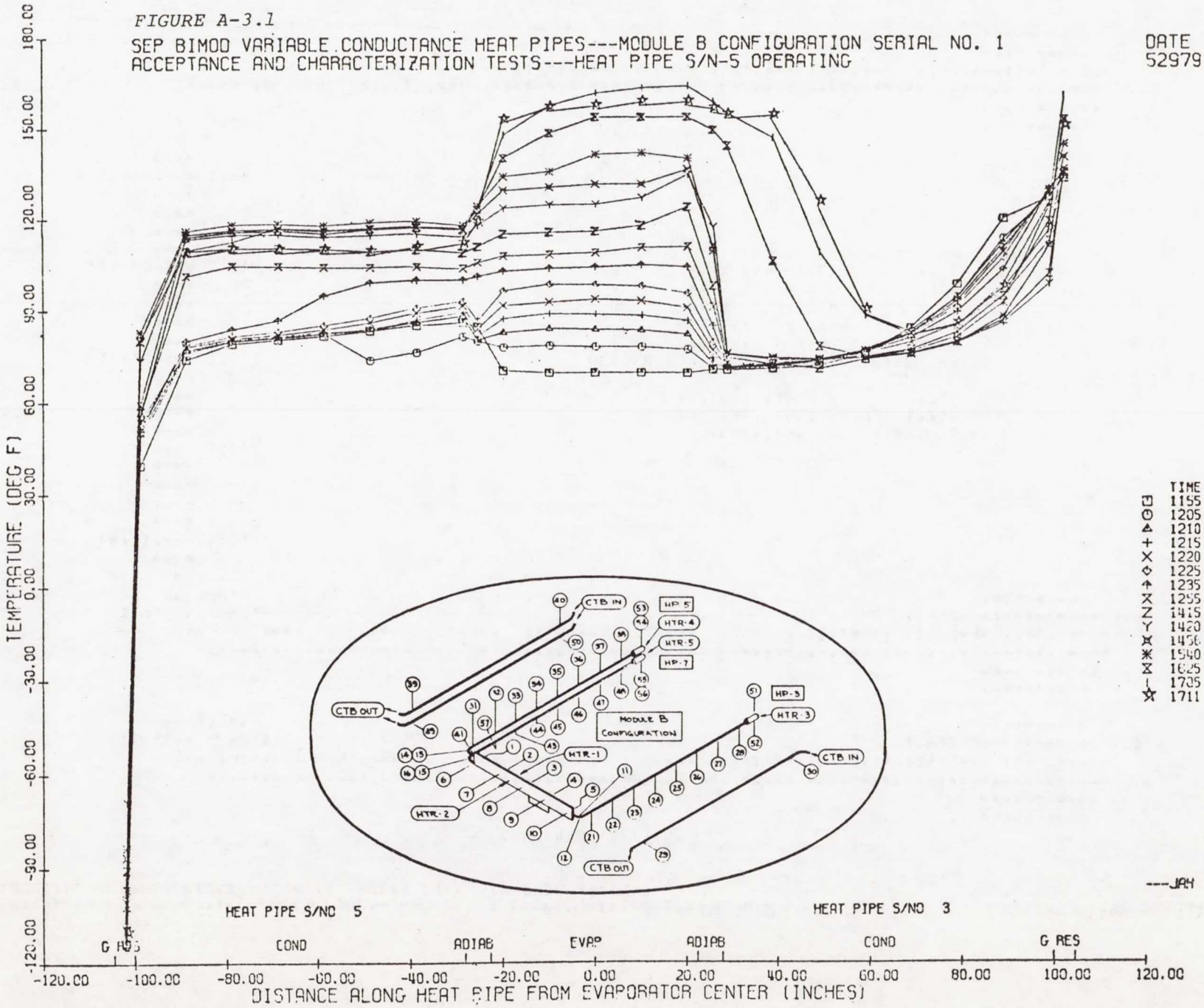


FIGURE A-3.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

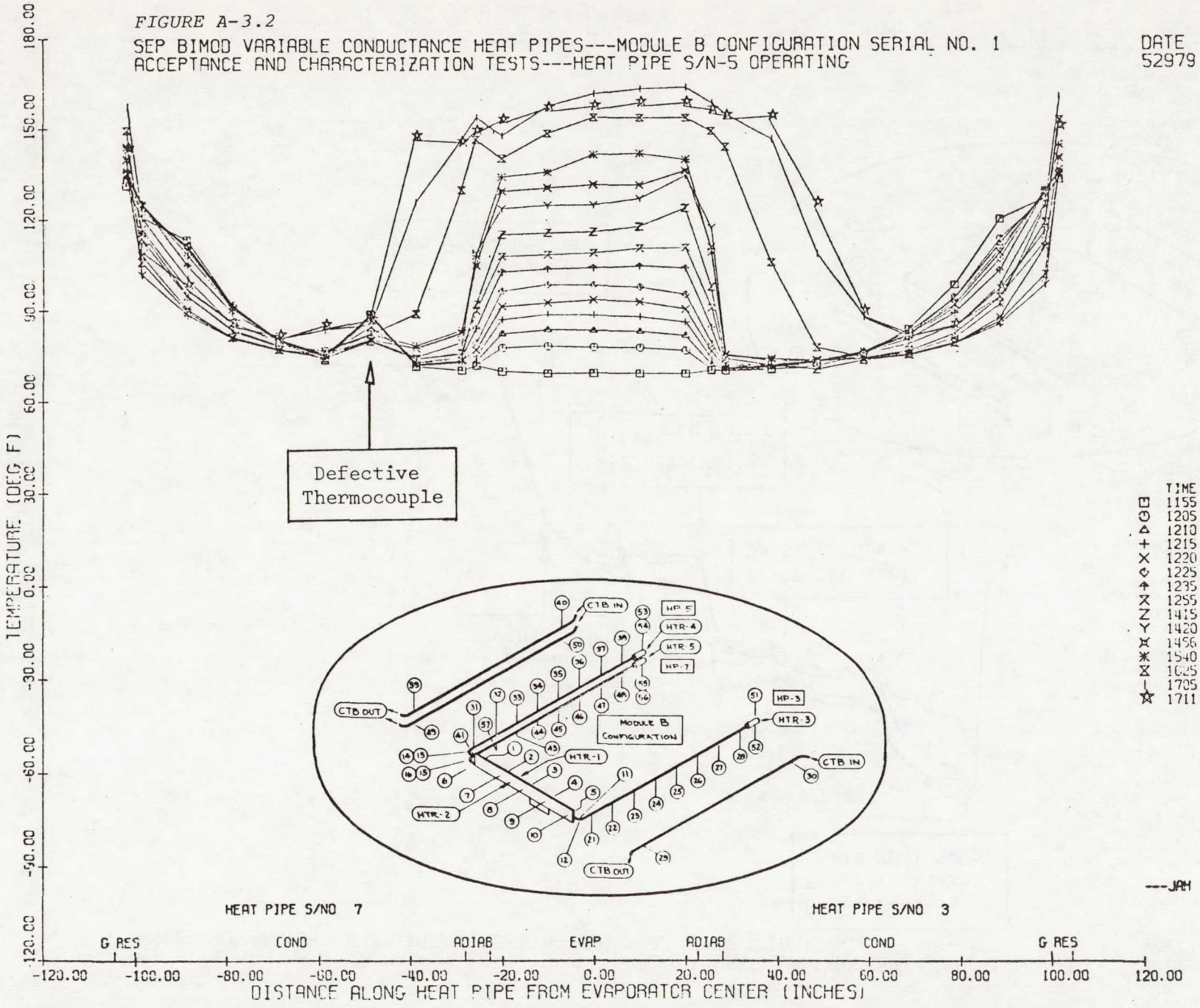


FIGURE A-3.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

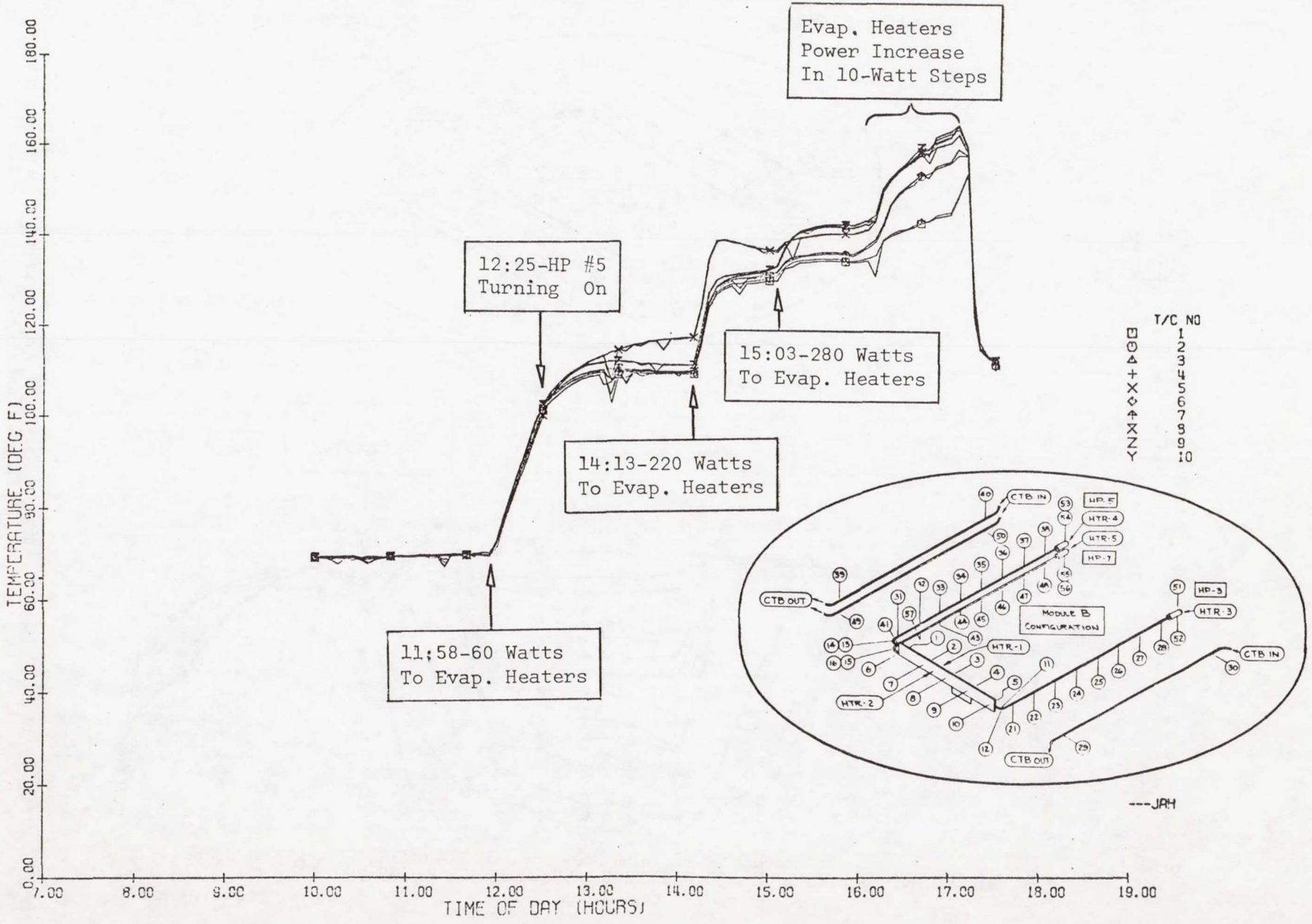


FIGURE A-3.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

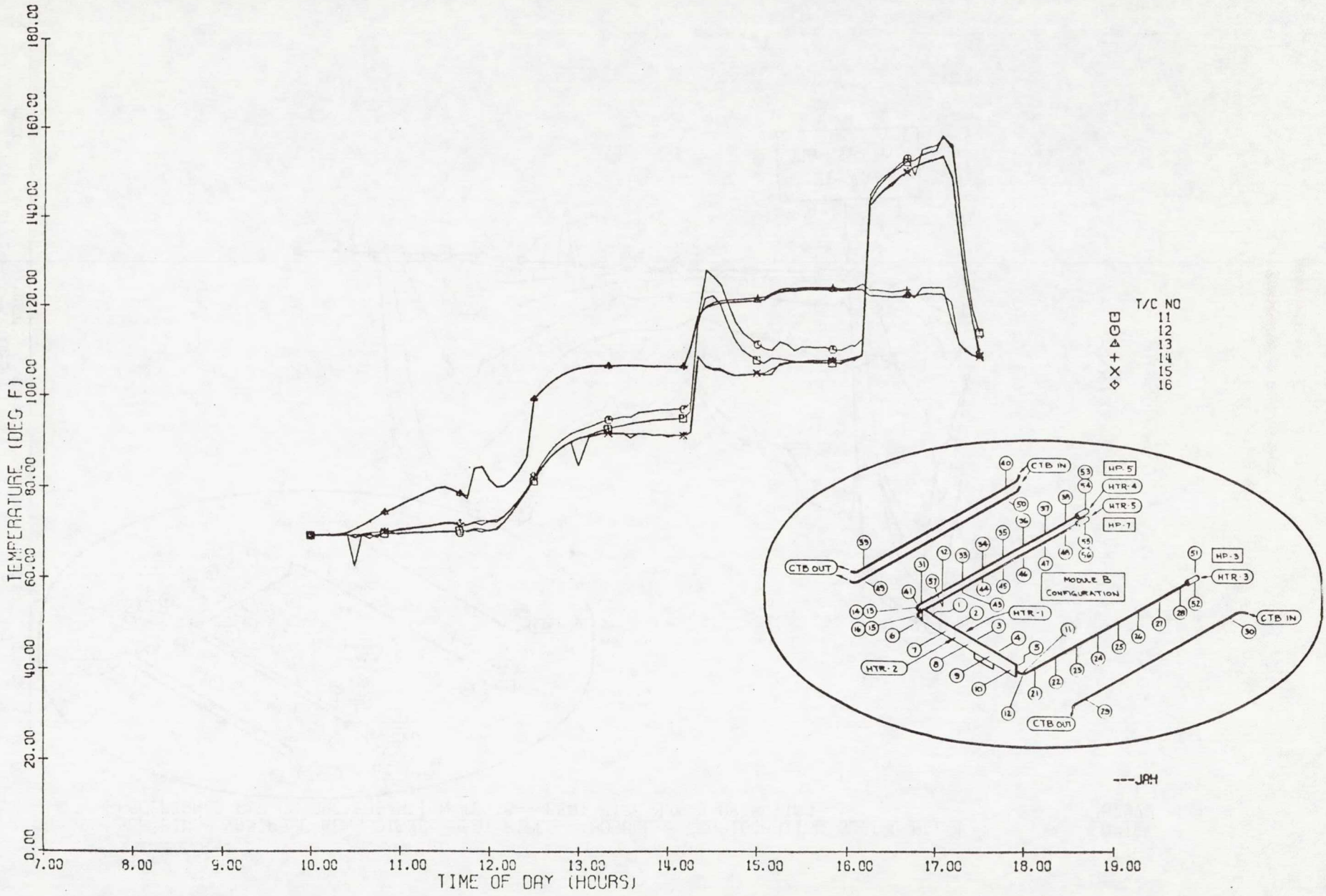


FIGURE A-3.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

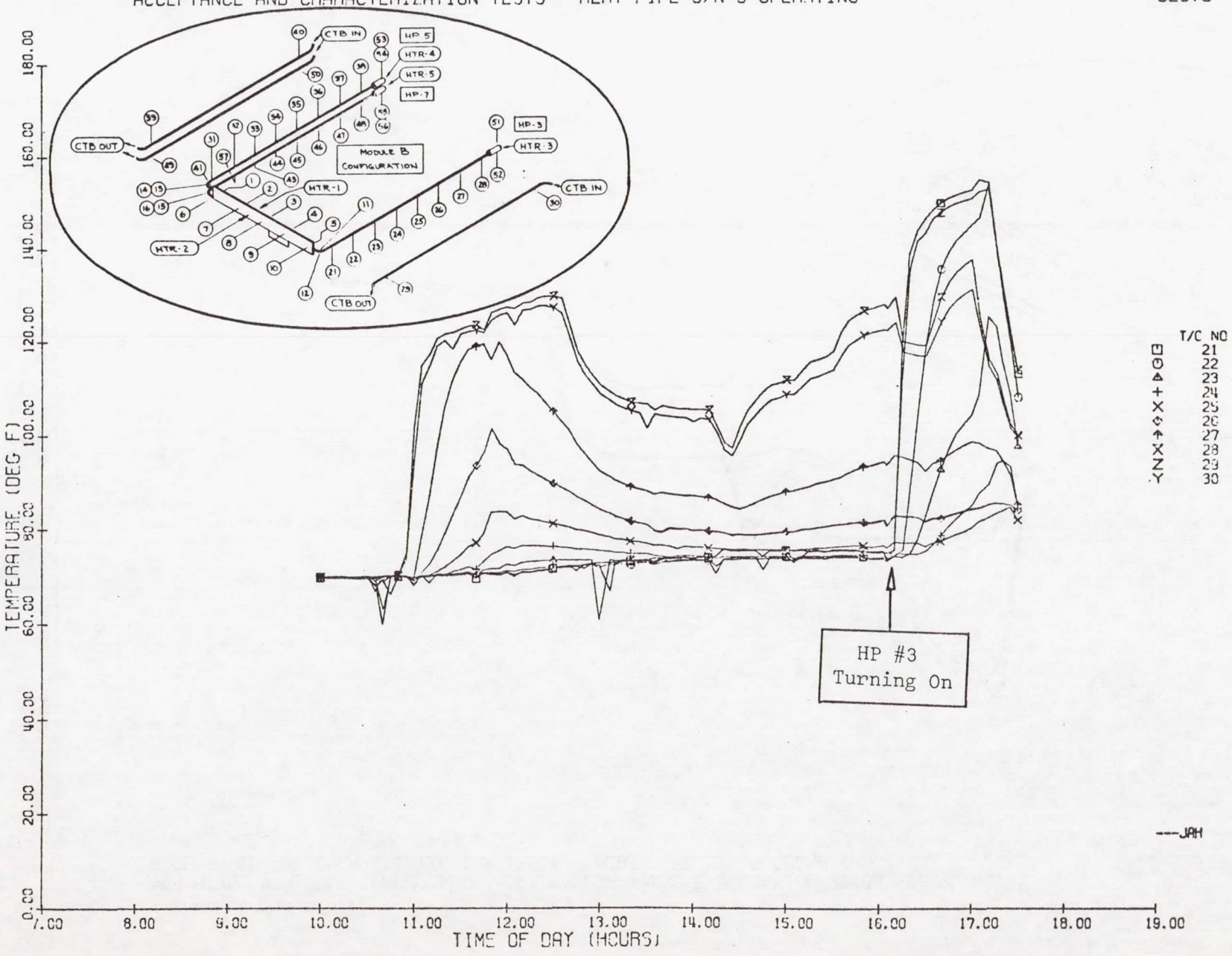


FIGURE A-3.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

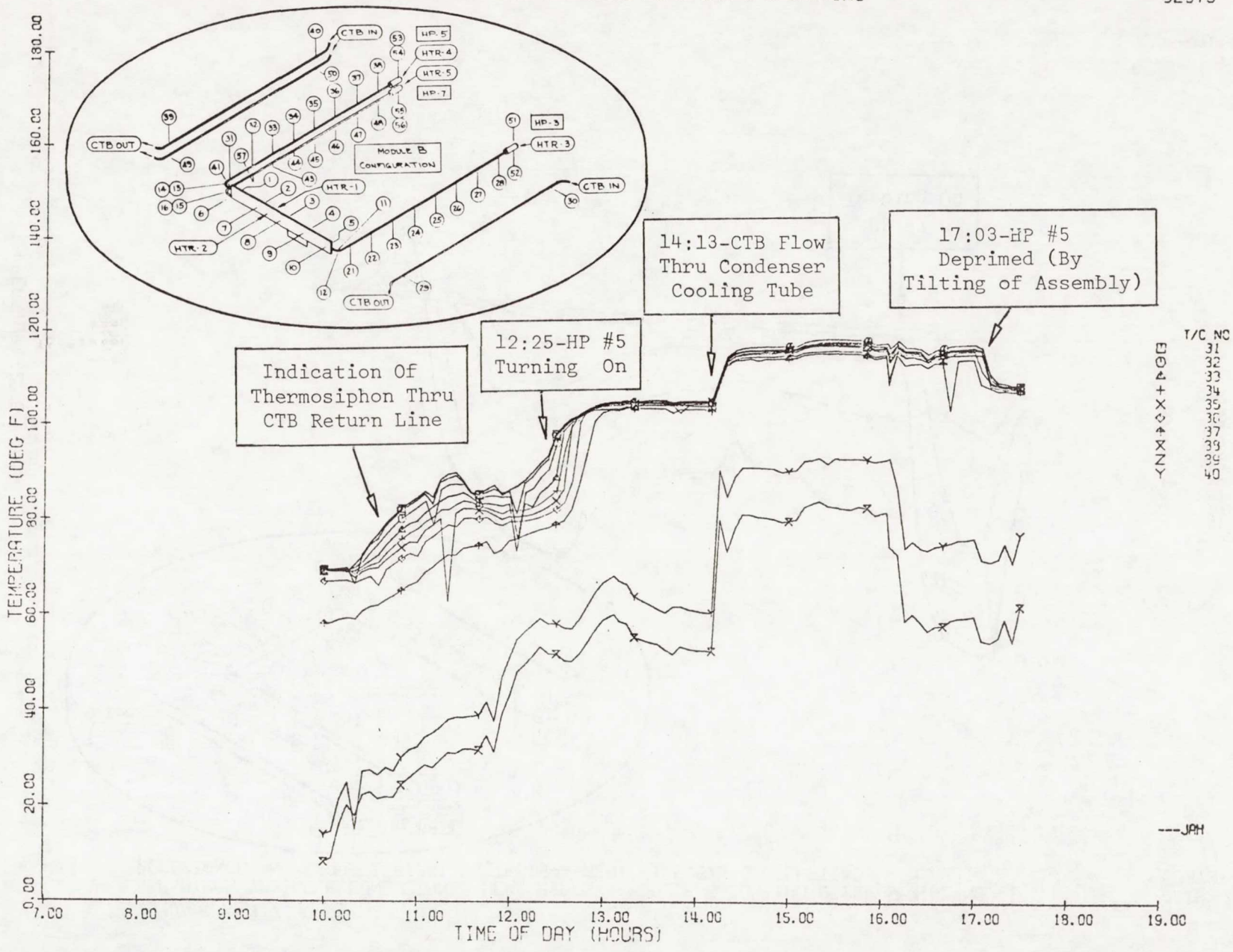


FIGURE A-3.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

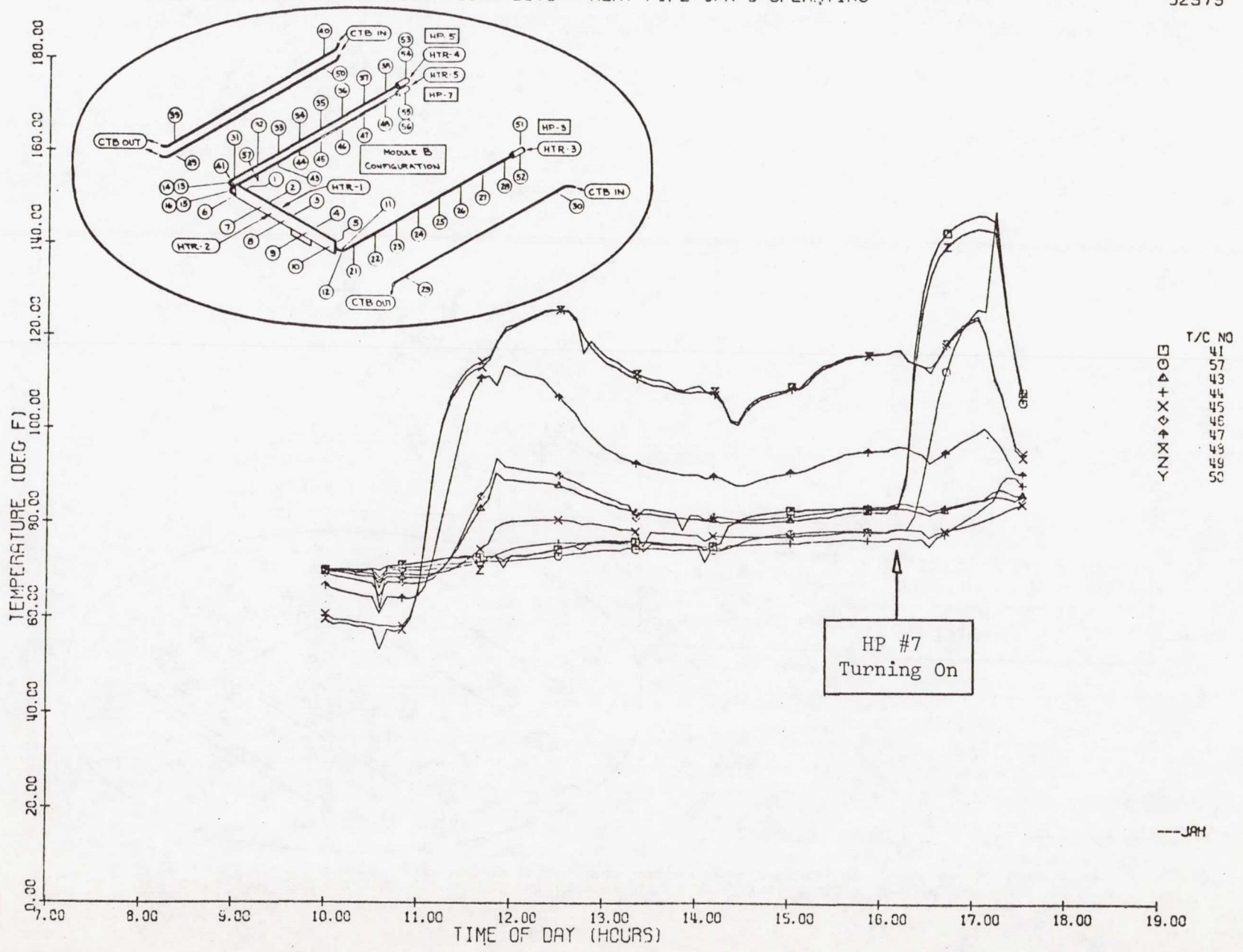


FIGURE A-3.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

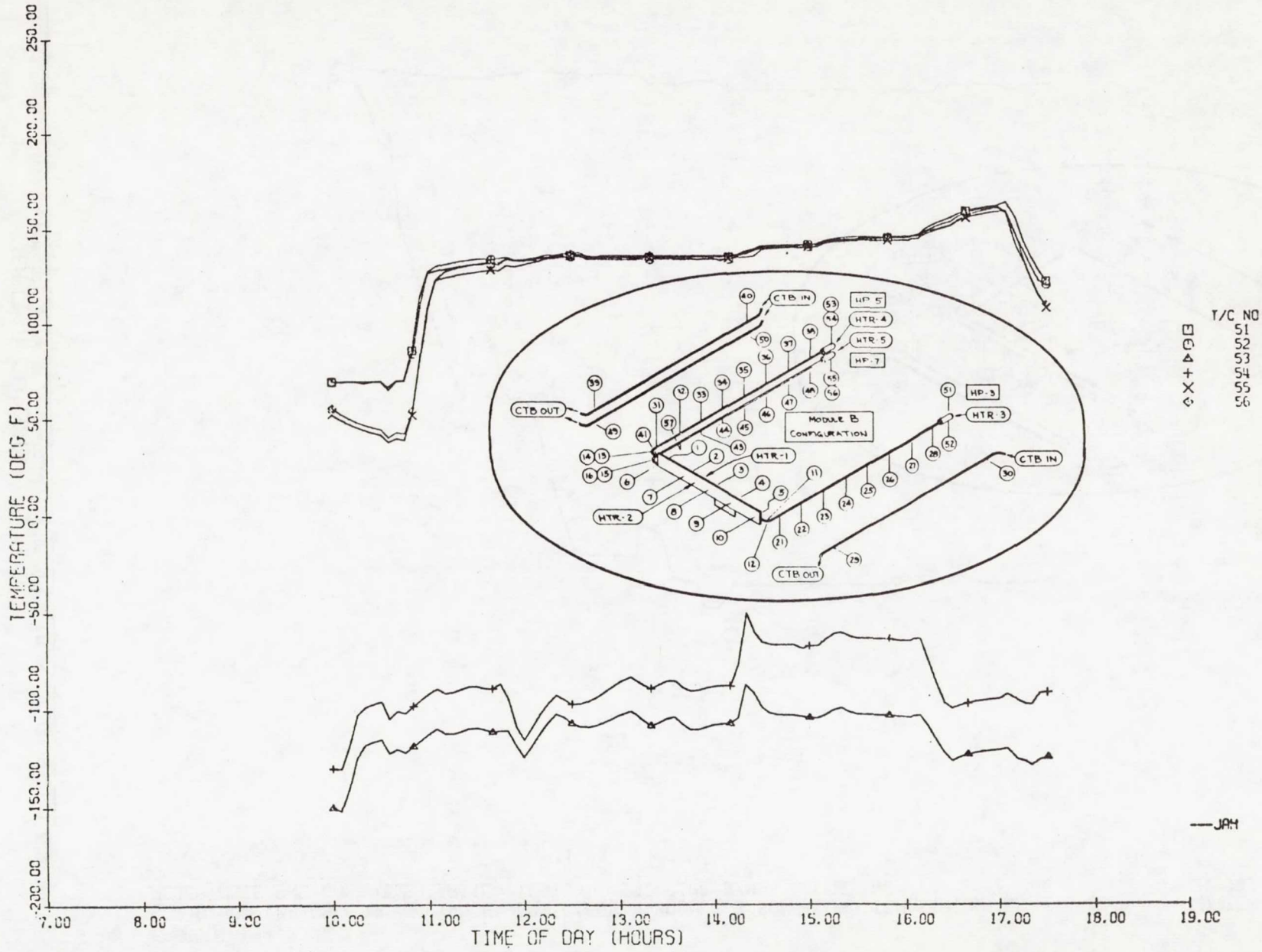


FIGURE A-3.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

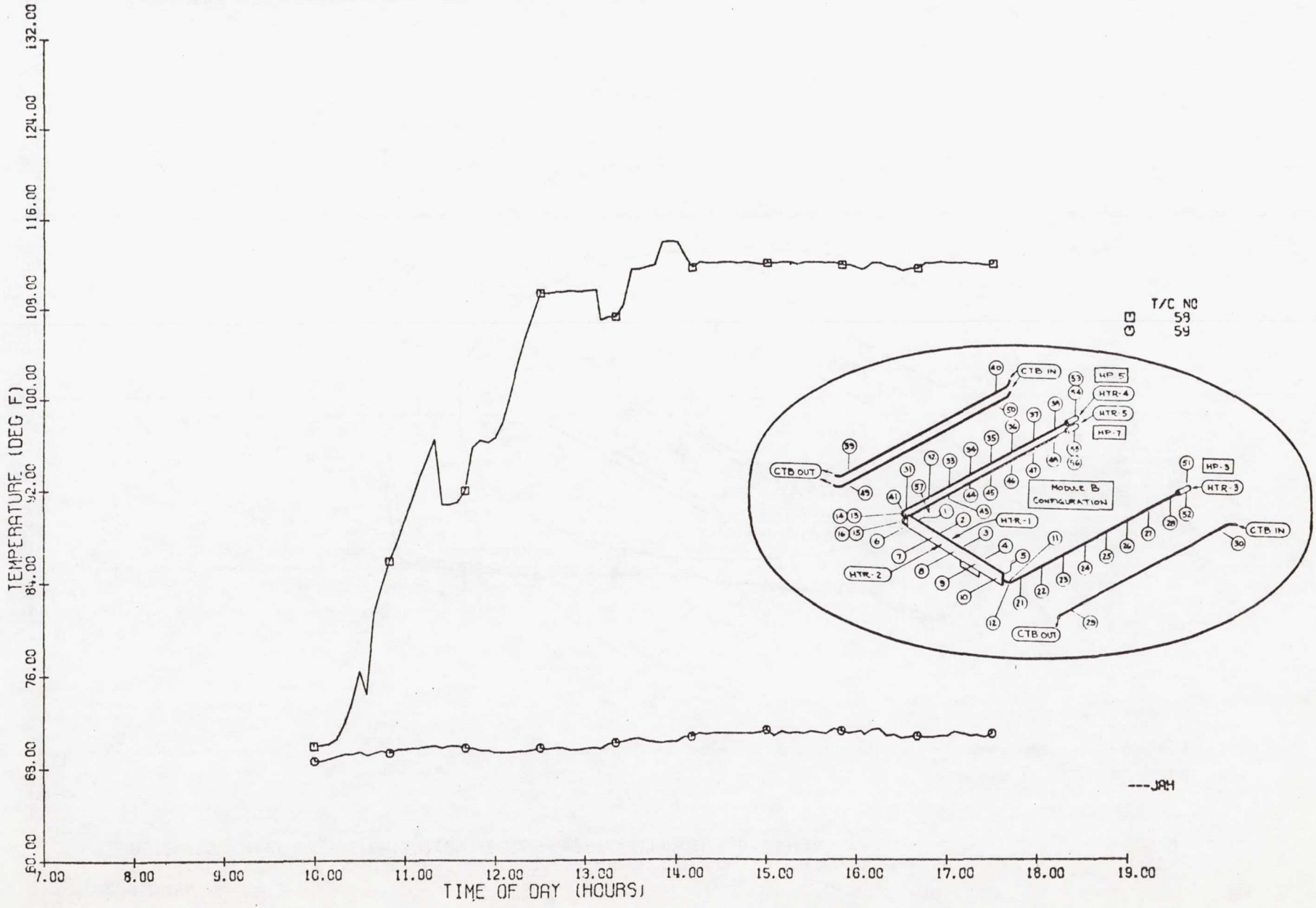


FIGURE A-3.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

DATE
52979

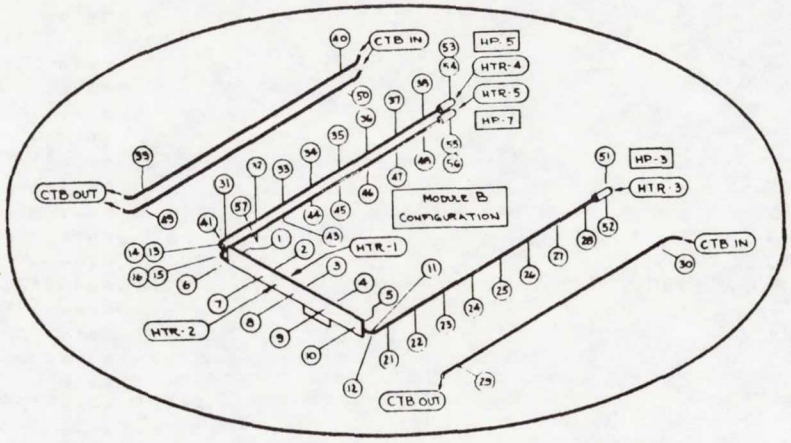
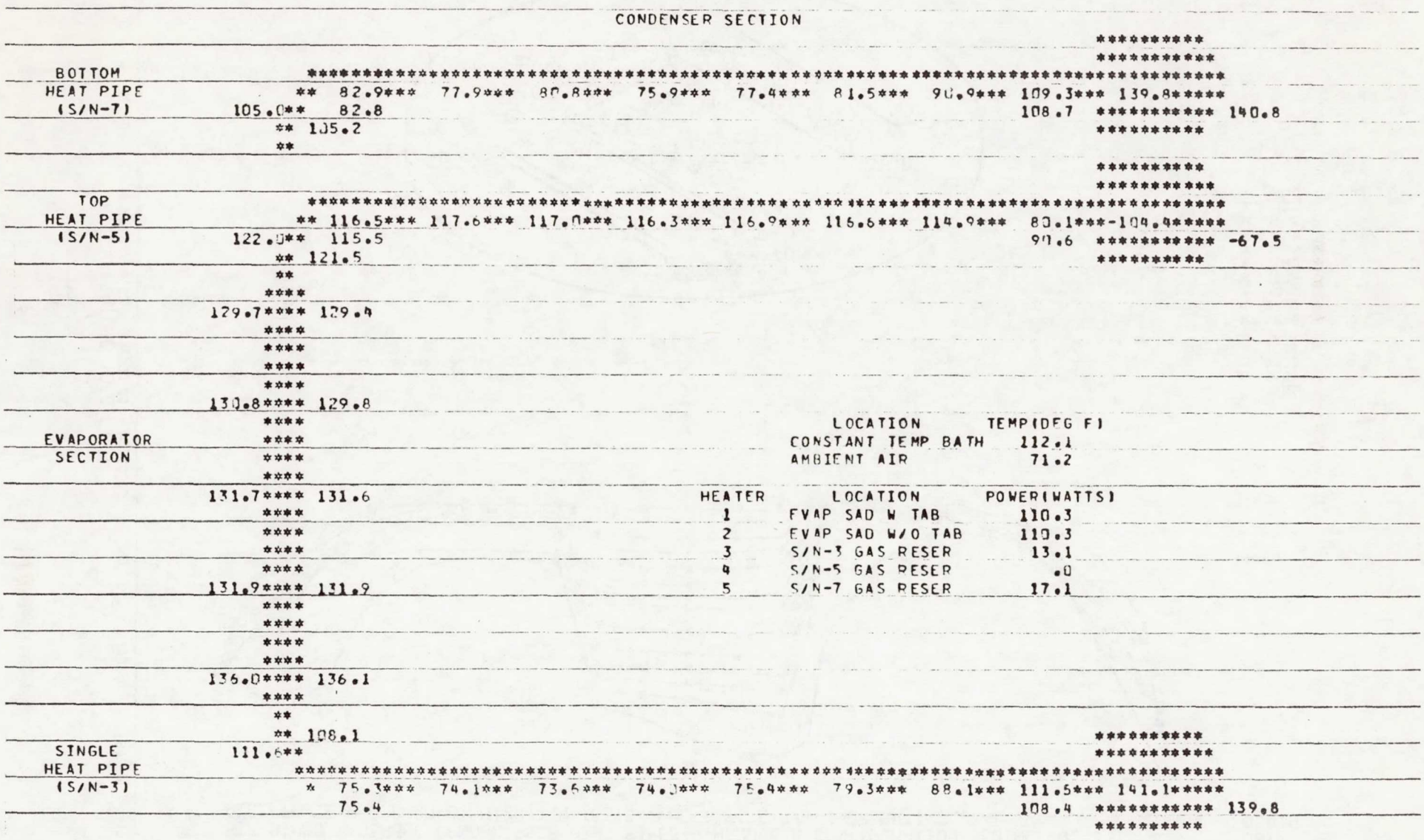


FIGURE A-3.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 52979 TIME = 1230
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING

FIGURE A-3.12

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 52979 TIME = 1500
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-5 OPERATING



LOCATION	TEMP(DEG F)
CONSTANT TEMP BATH	112.1
AMBIENT AIR	71.2

HEATER	LOCATION	POWER(WATTS)
1	EVAP SAD W TAB	110.3
2	EVAP SAD W/O TAB	110.3
3	S/N-3 GAS RESER	13.1
4	S/N-5 GAS RESER	.0
5	S/N-7 GAS RESER	17.1

FIGURE A-4.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

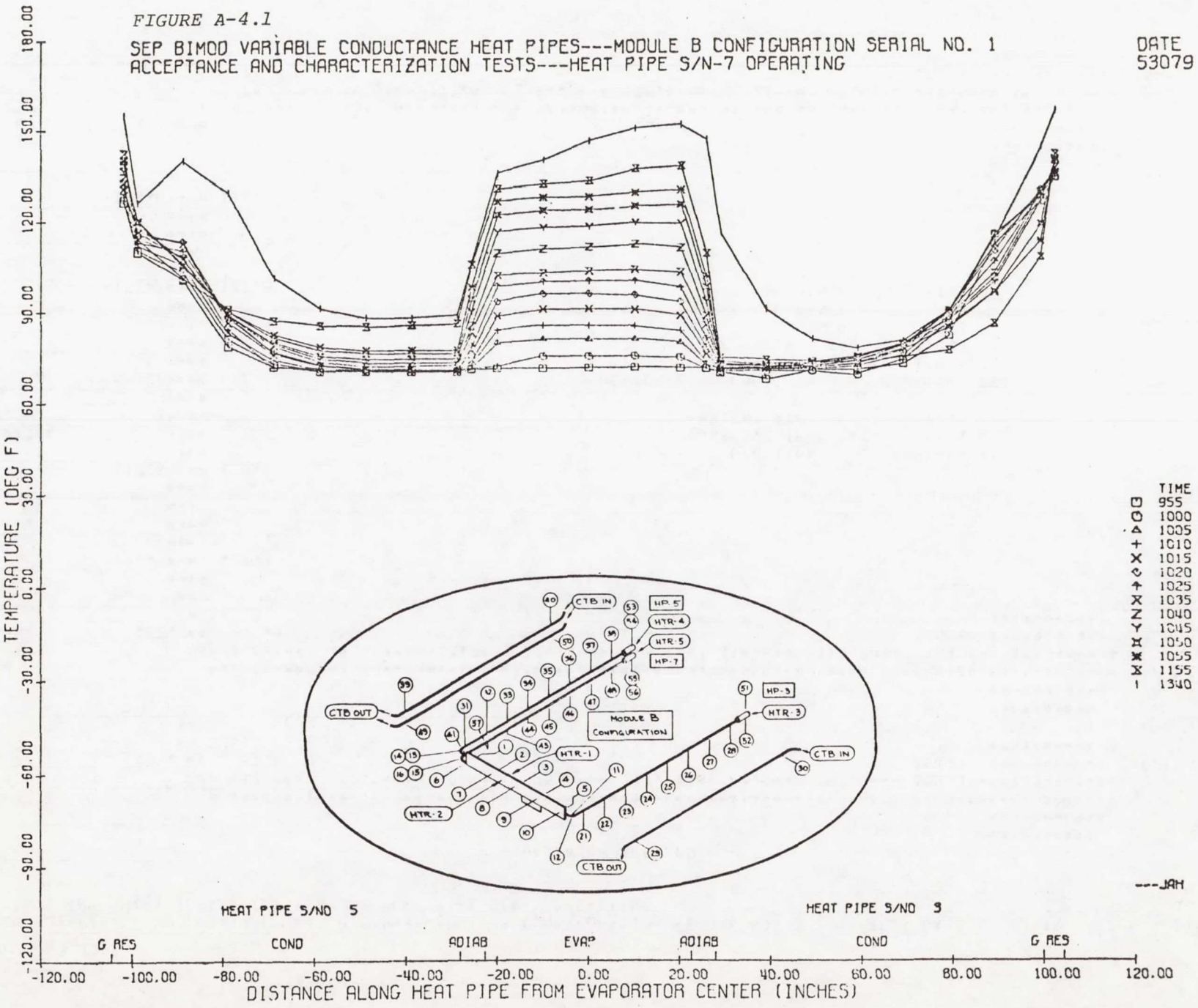


FIGURE A-4.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

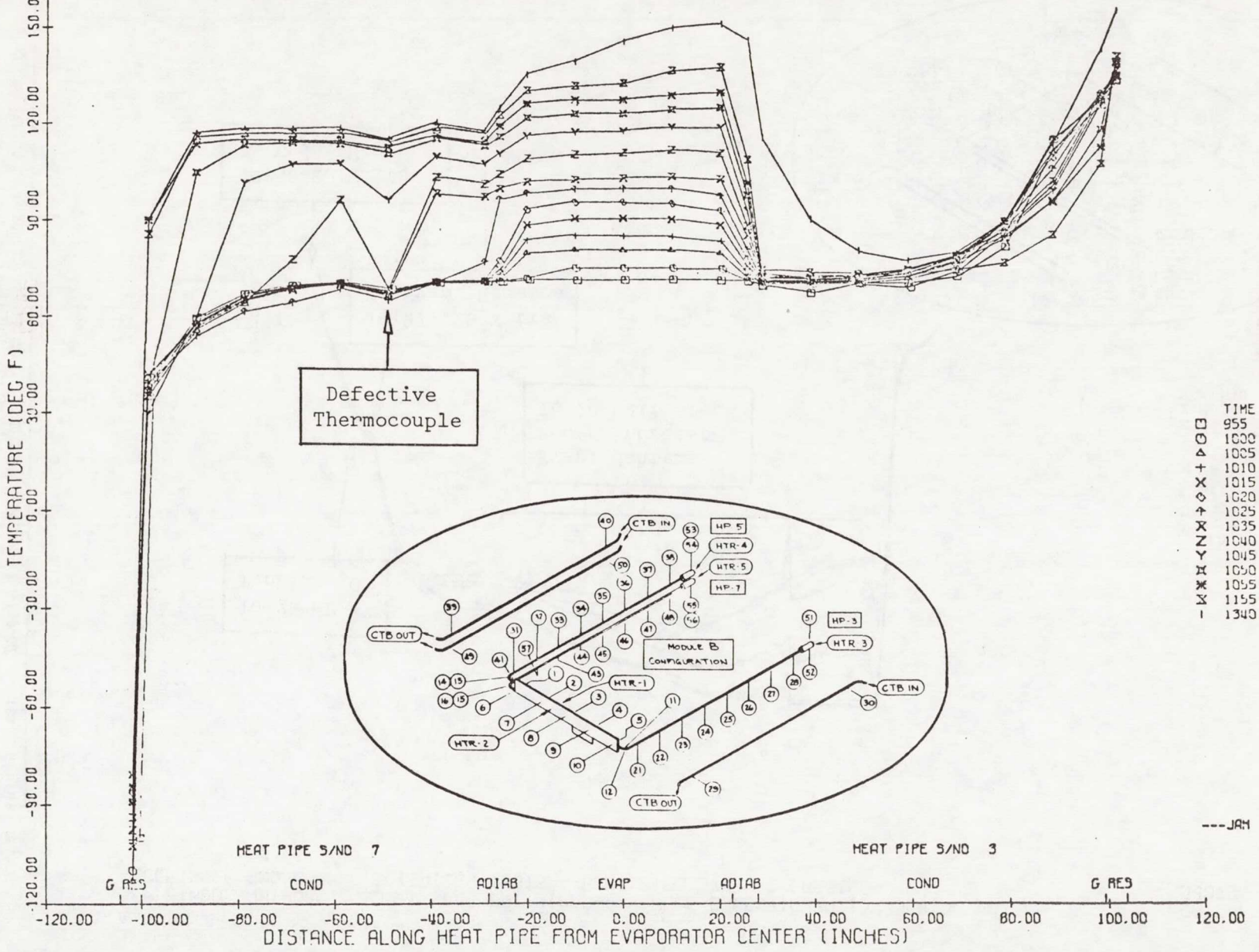


FIGURE A-4.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

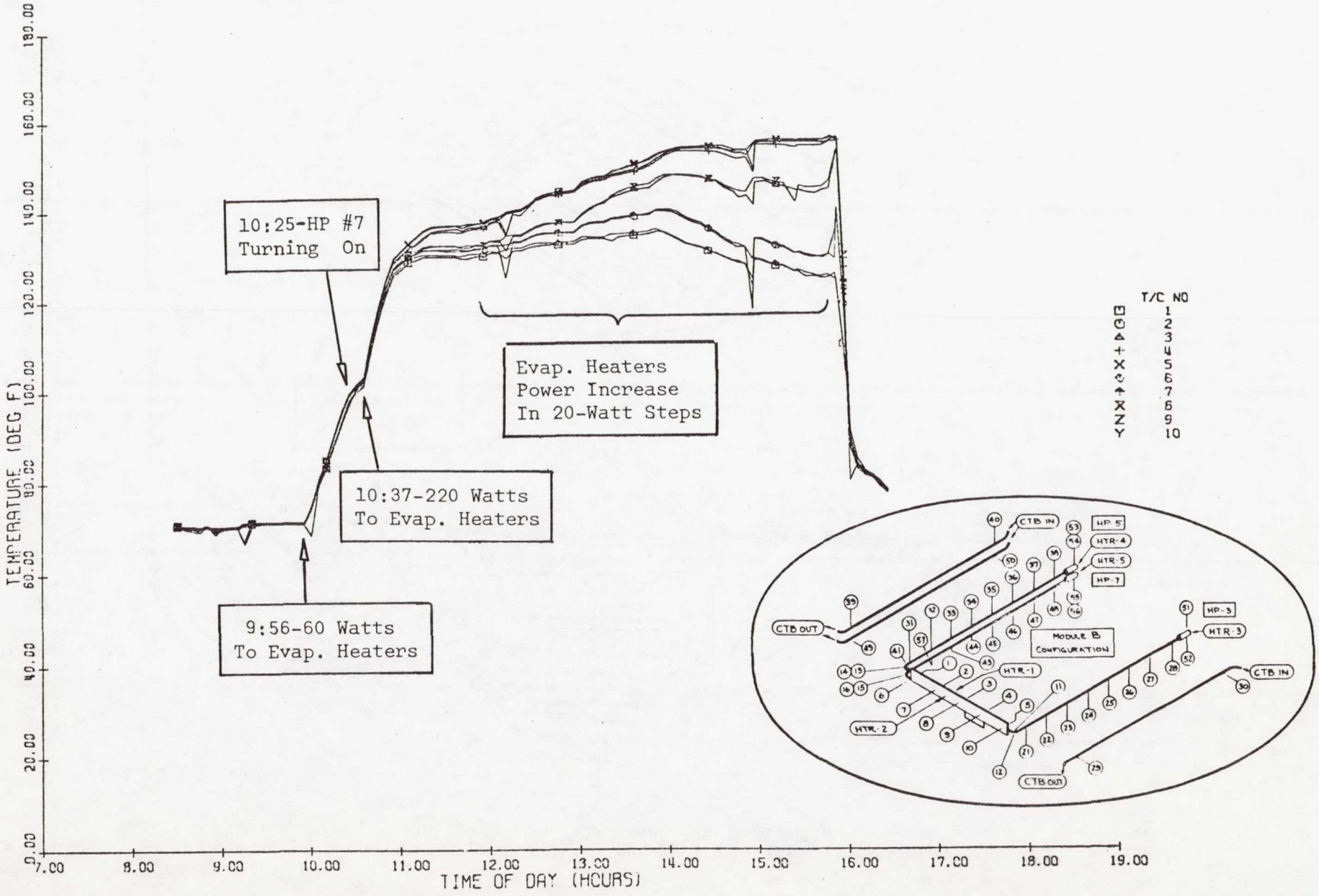


FIGURE A-4.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS----HEAT PIPE S/N-7 OPERATING

DATE
53079

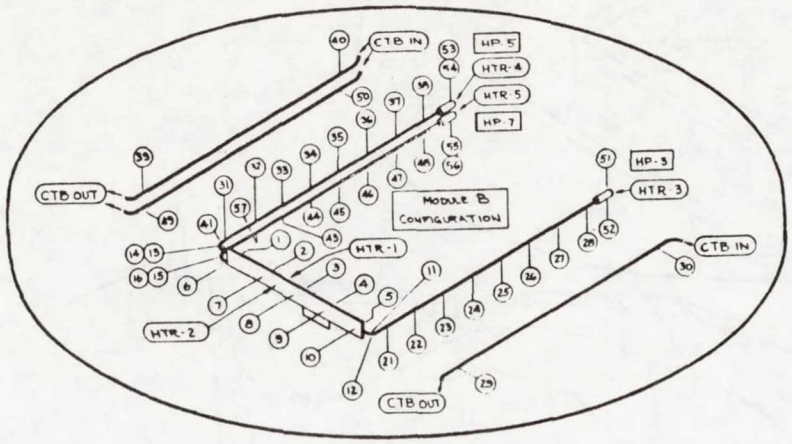


FIGURE A-4.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

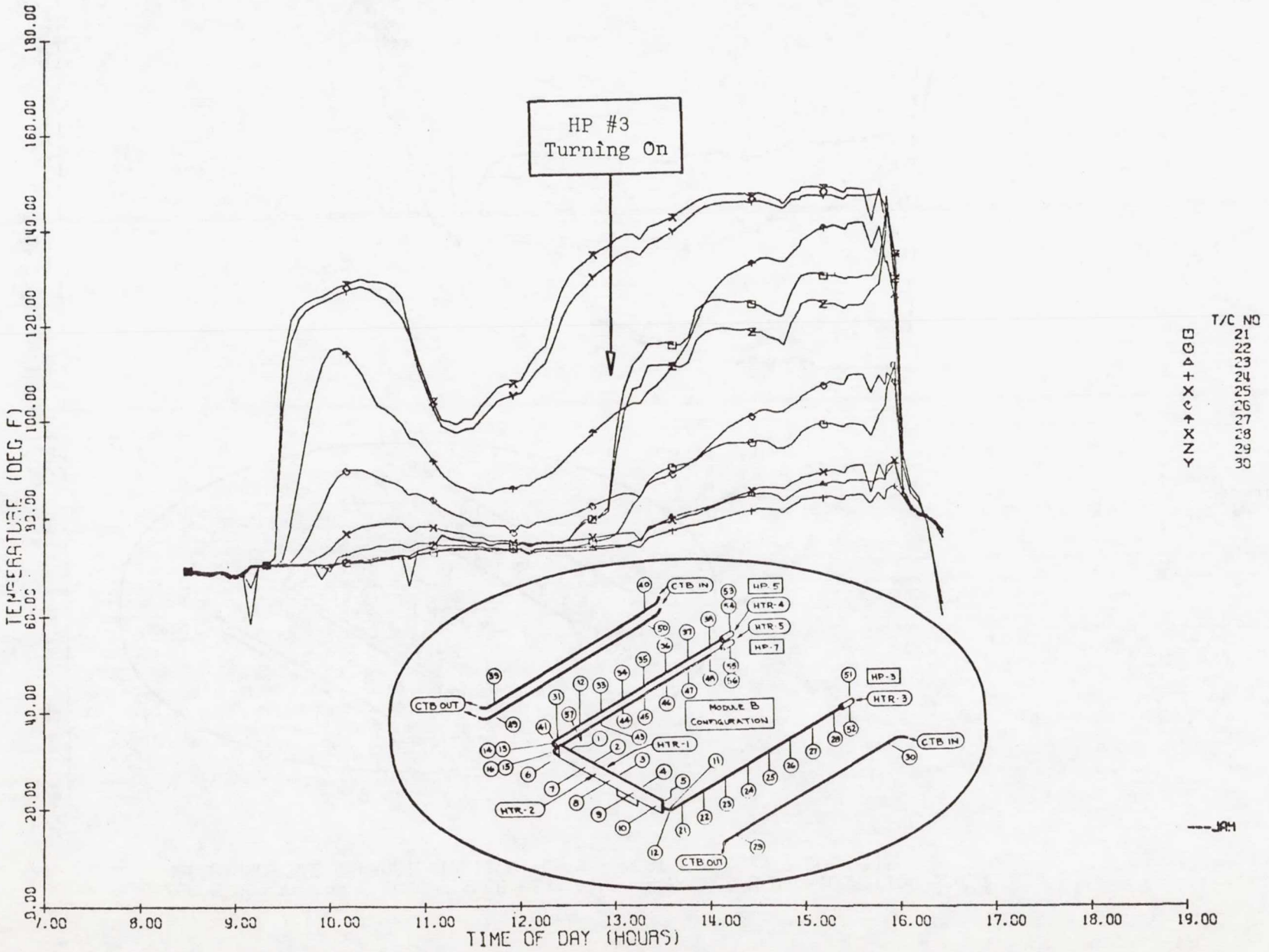


FIGURE A-4.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE 53079

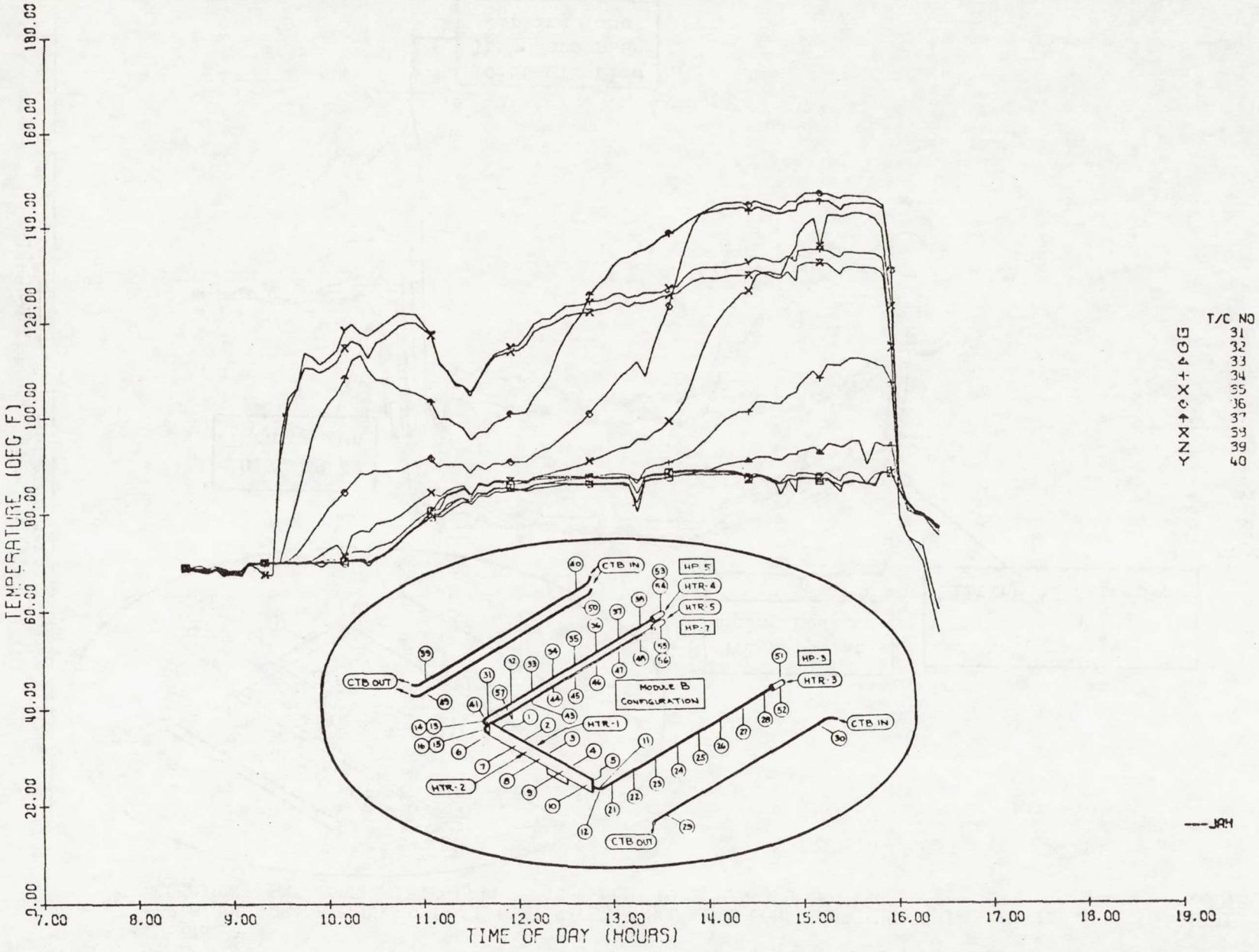


FIGURE A-4.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

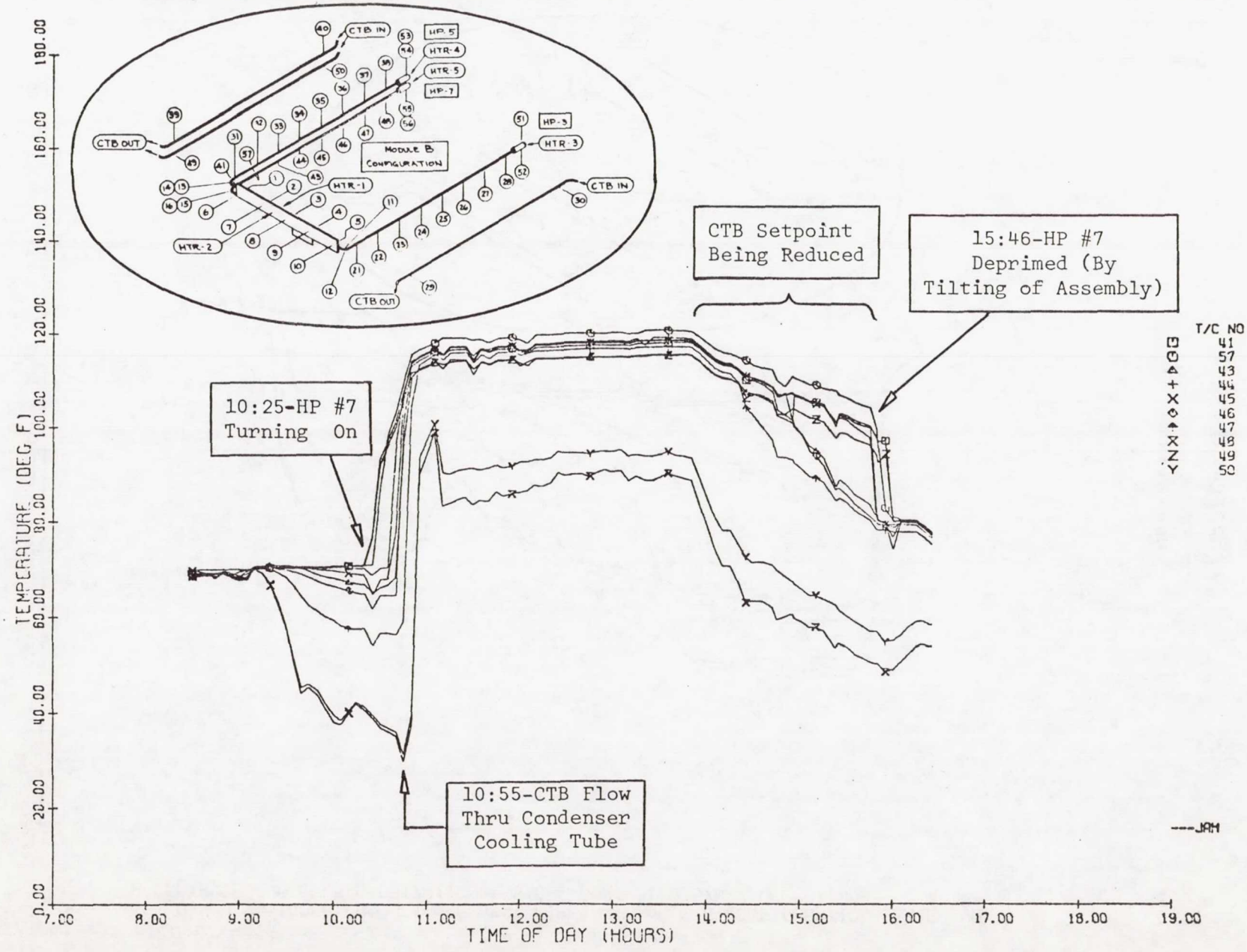


FIGURE A-4.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

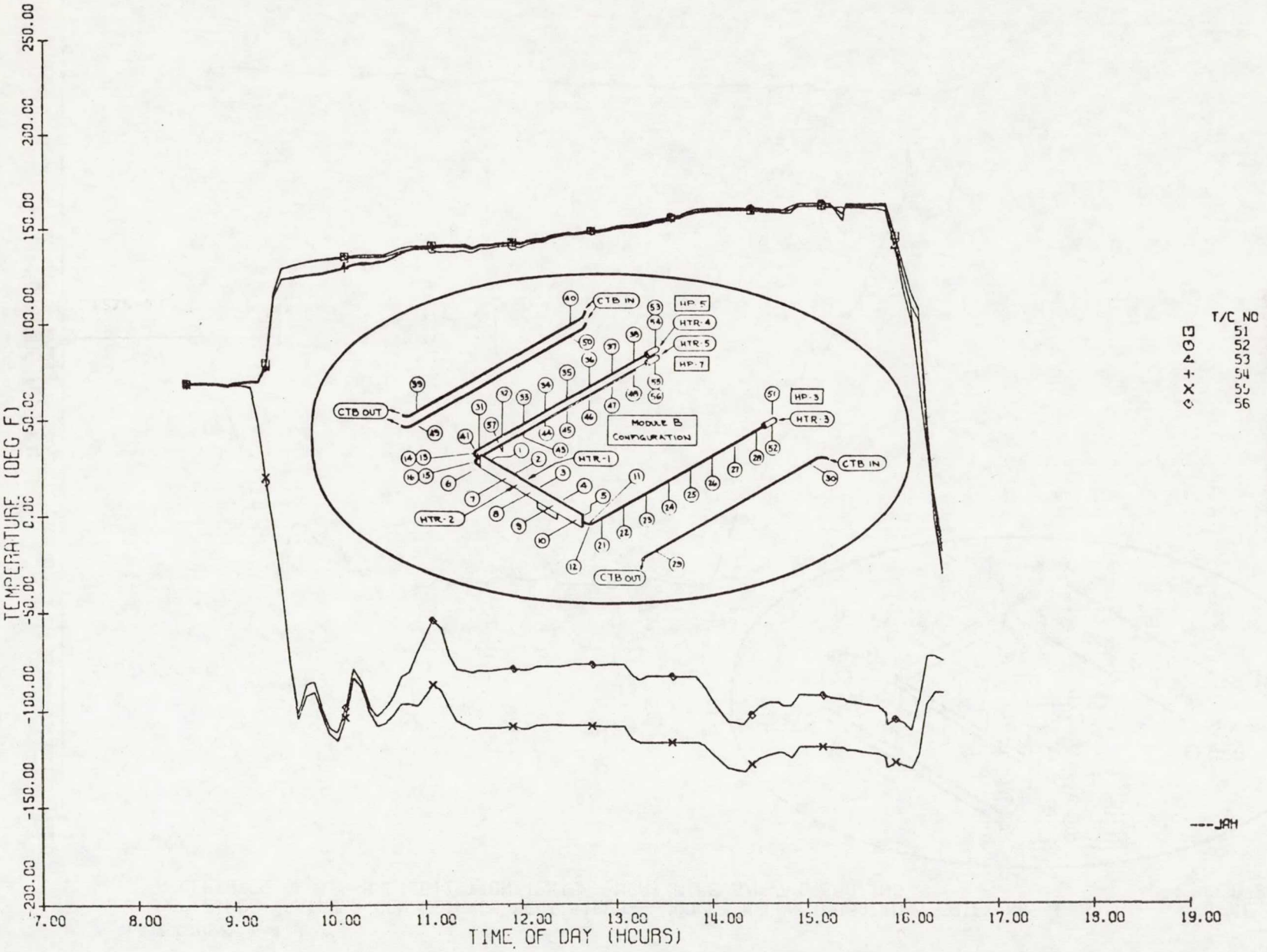


FIGURE A-4.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

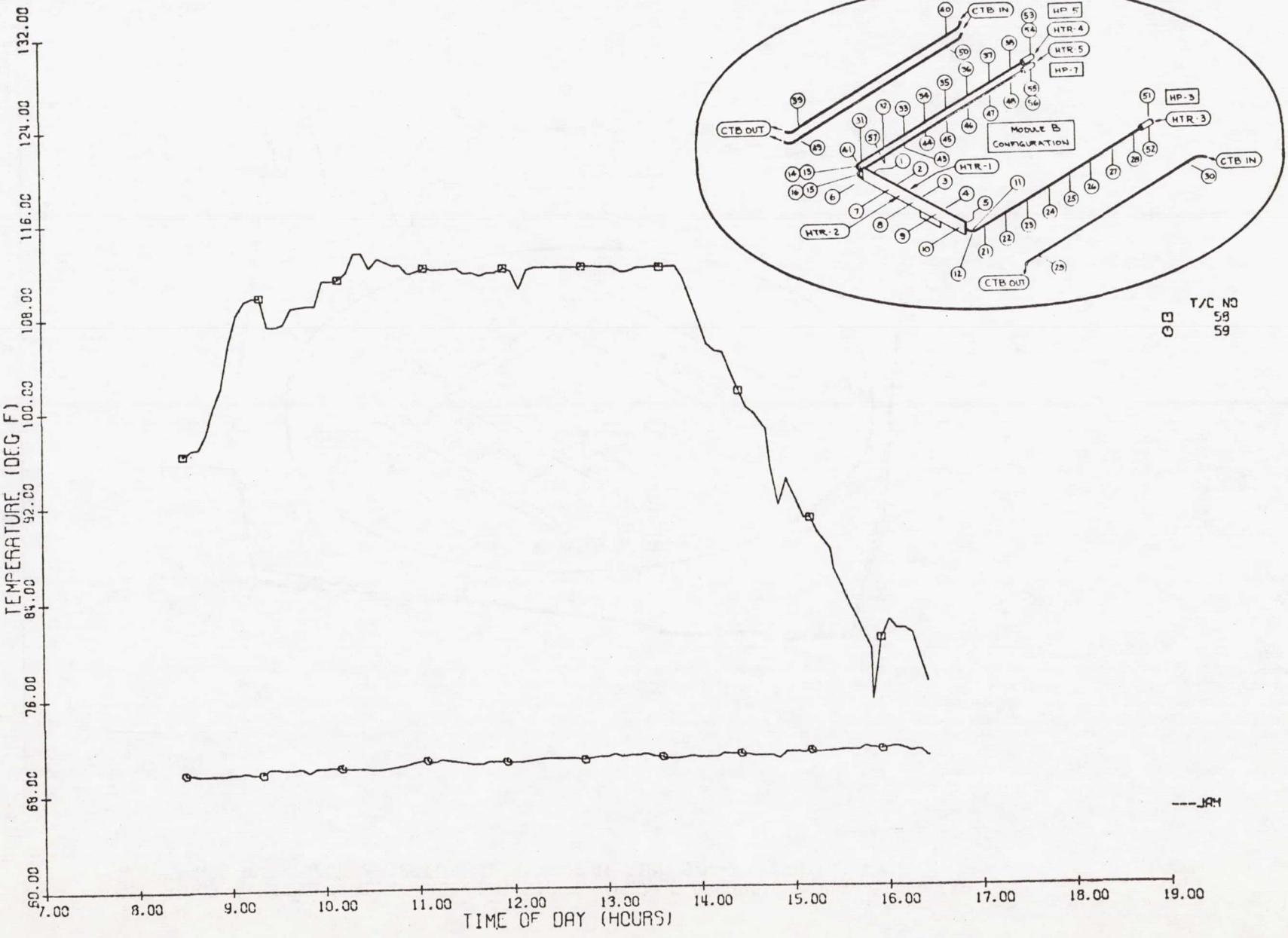


FIGURE A-4.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

DATE
53079

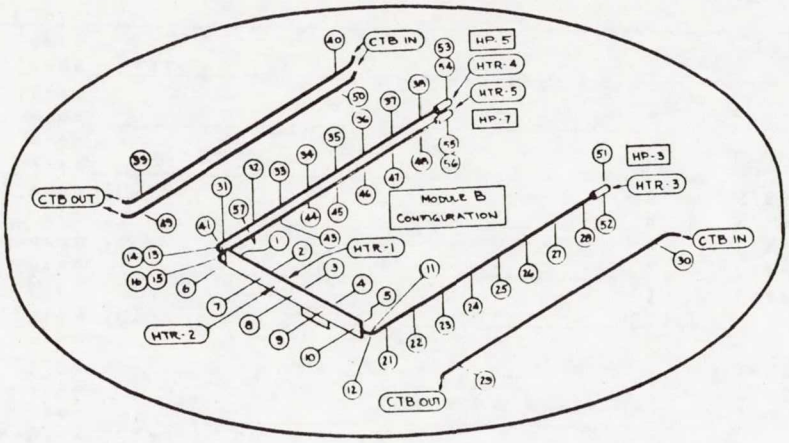
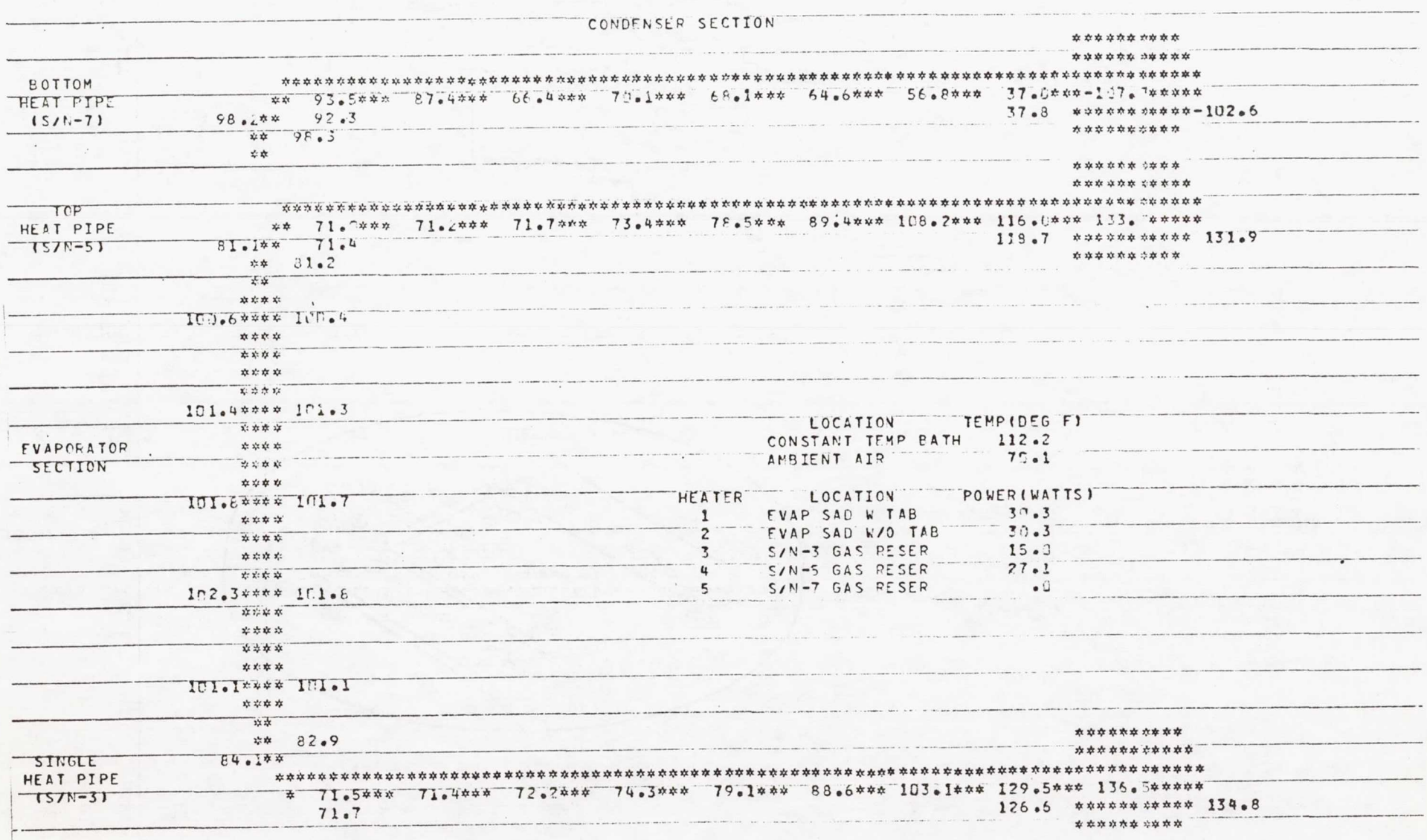


FIGURE A-4.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 53079 TIME = 1030
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING



LOCATION	TEMP(DEG F)
CONSTANT TEMP BATH	112.2
AMBIENT AIR	79.1

HEATER	LOCATION	POWER(WATTS)
1	EVAP SAD W TAB	30.3
2	EVAP SAD W/O TAB	30.3
3	S/N-3 GAS RESER	15.0
4	S/N-5 GAS RESER	27.1
5	S/N-7 GAS RESER	.0

FIGURE A-4.12

SEP PIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 53079 TIME = 1155
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-7 OPERATING

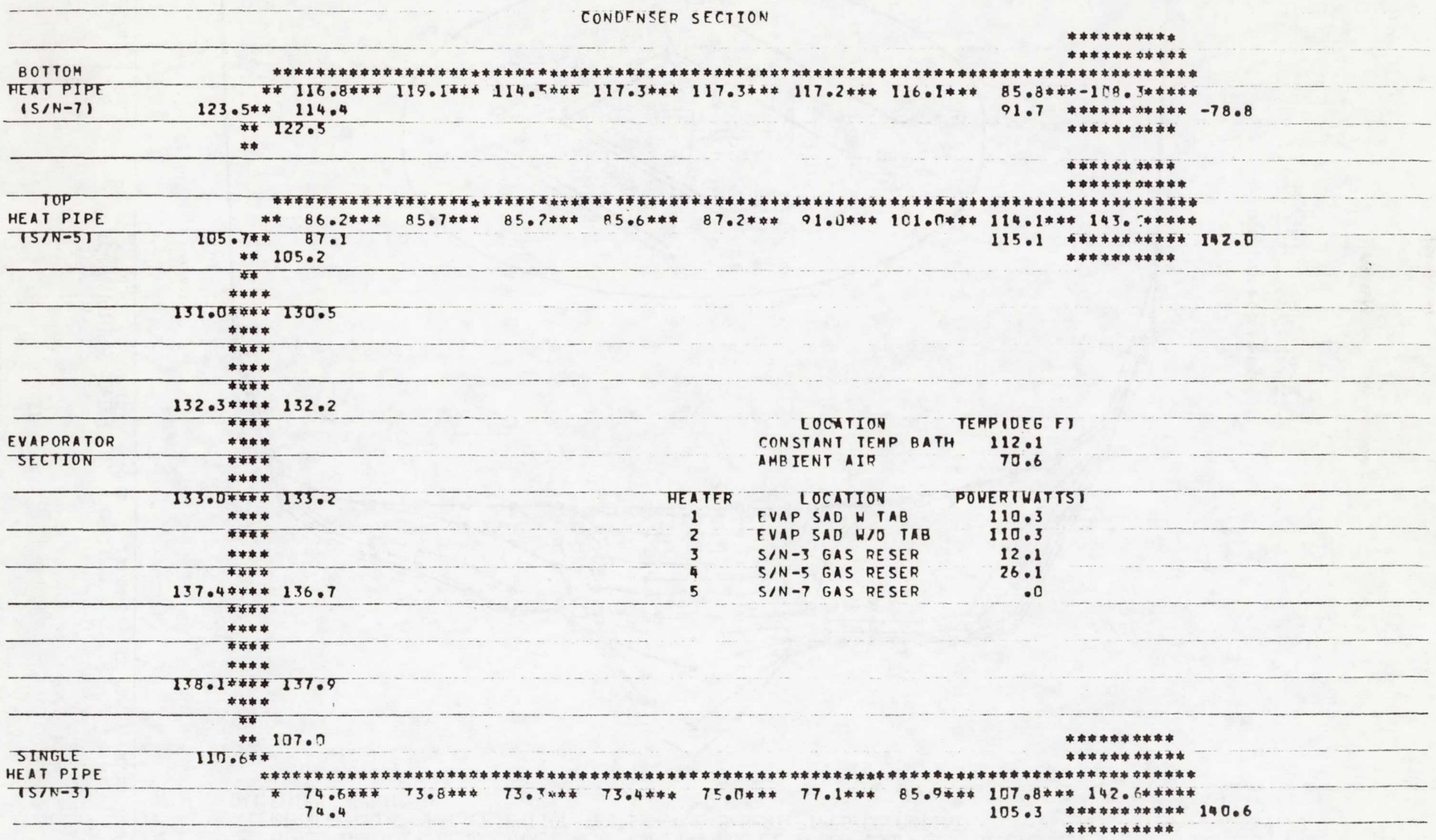


FIGURE A-5.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

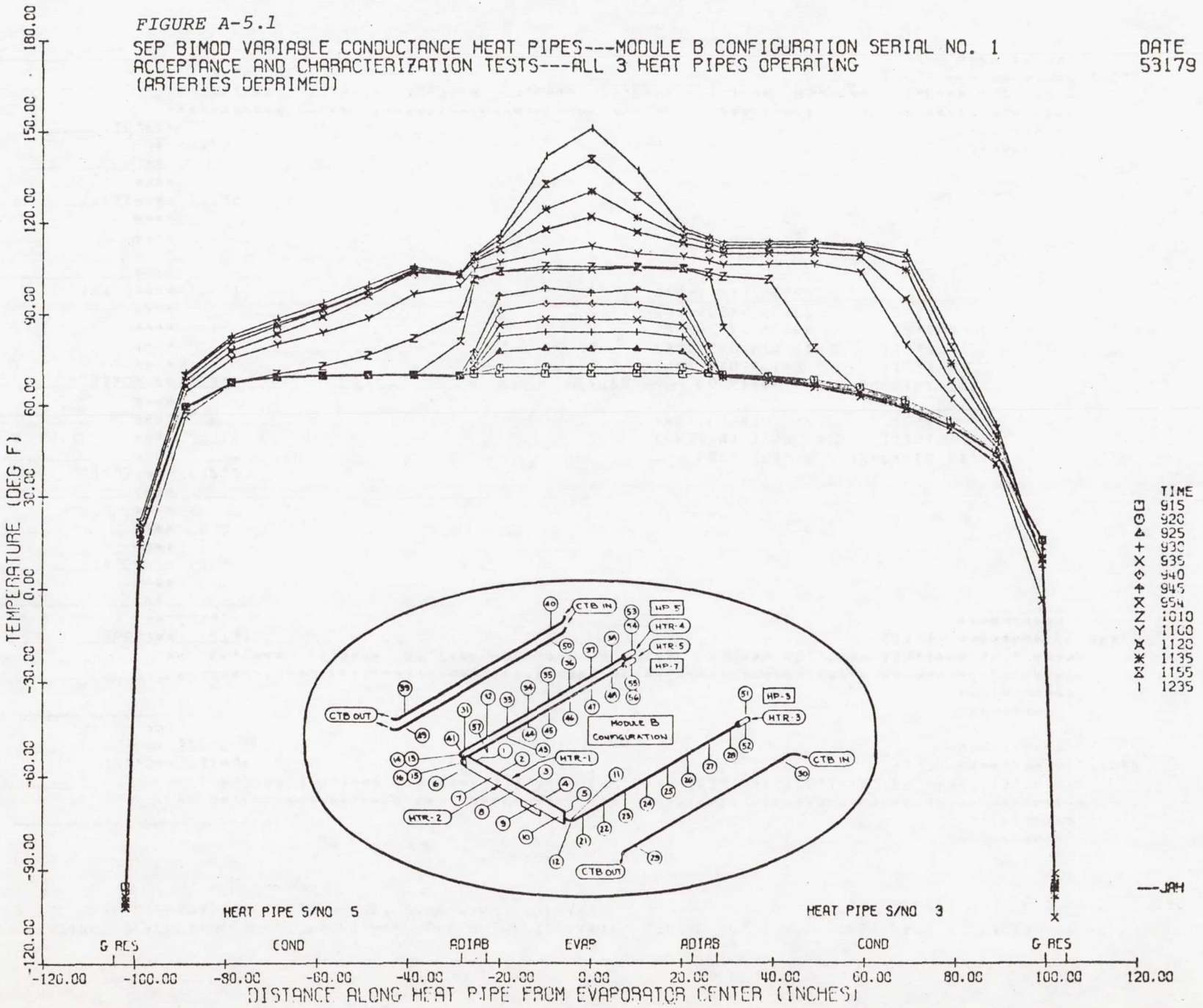


FIGURE A-5.2

SEP BIMCD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

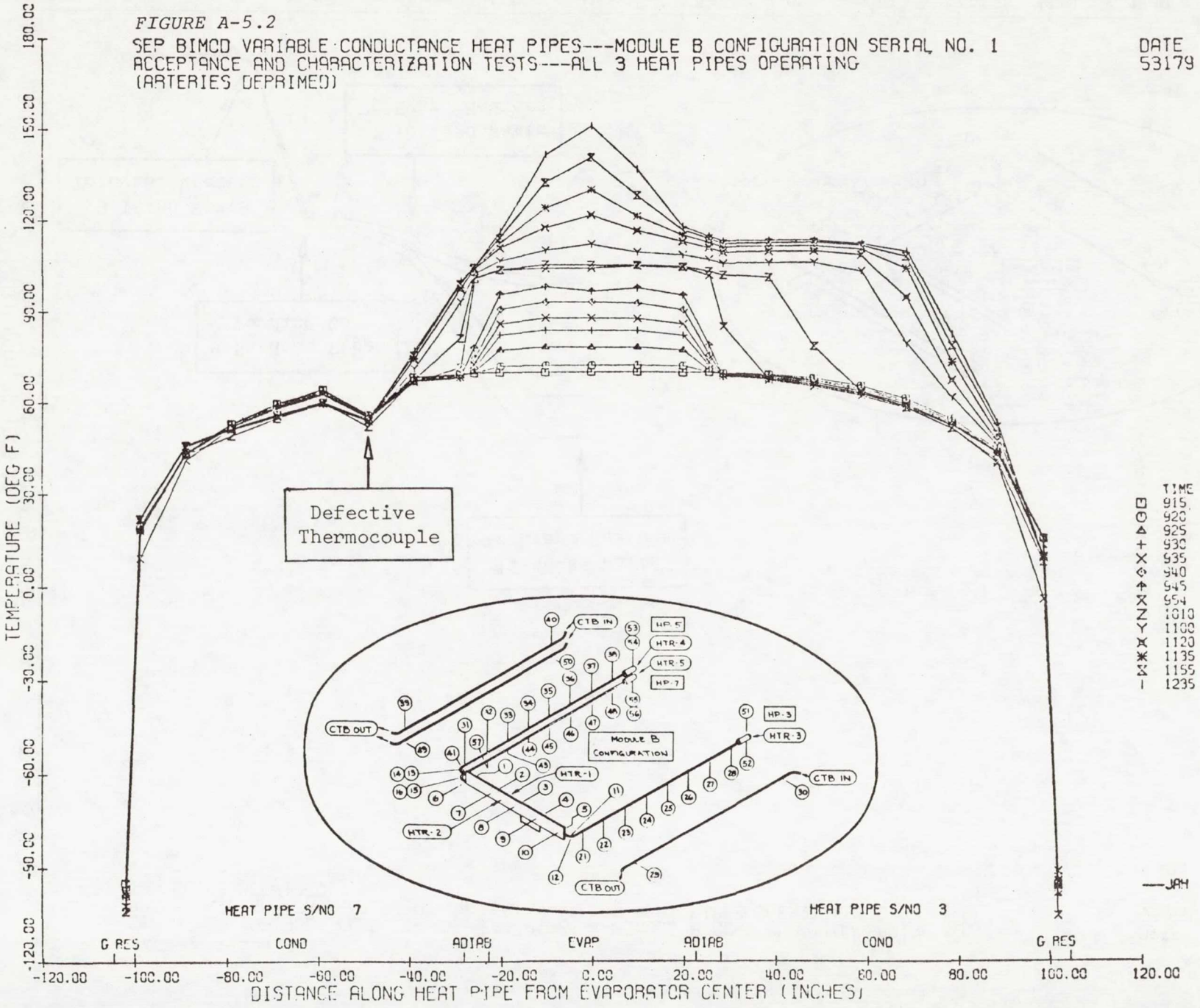
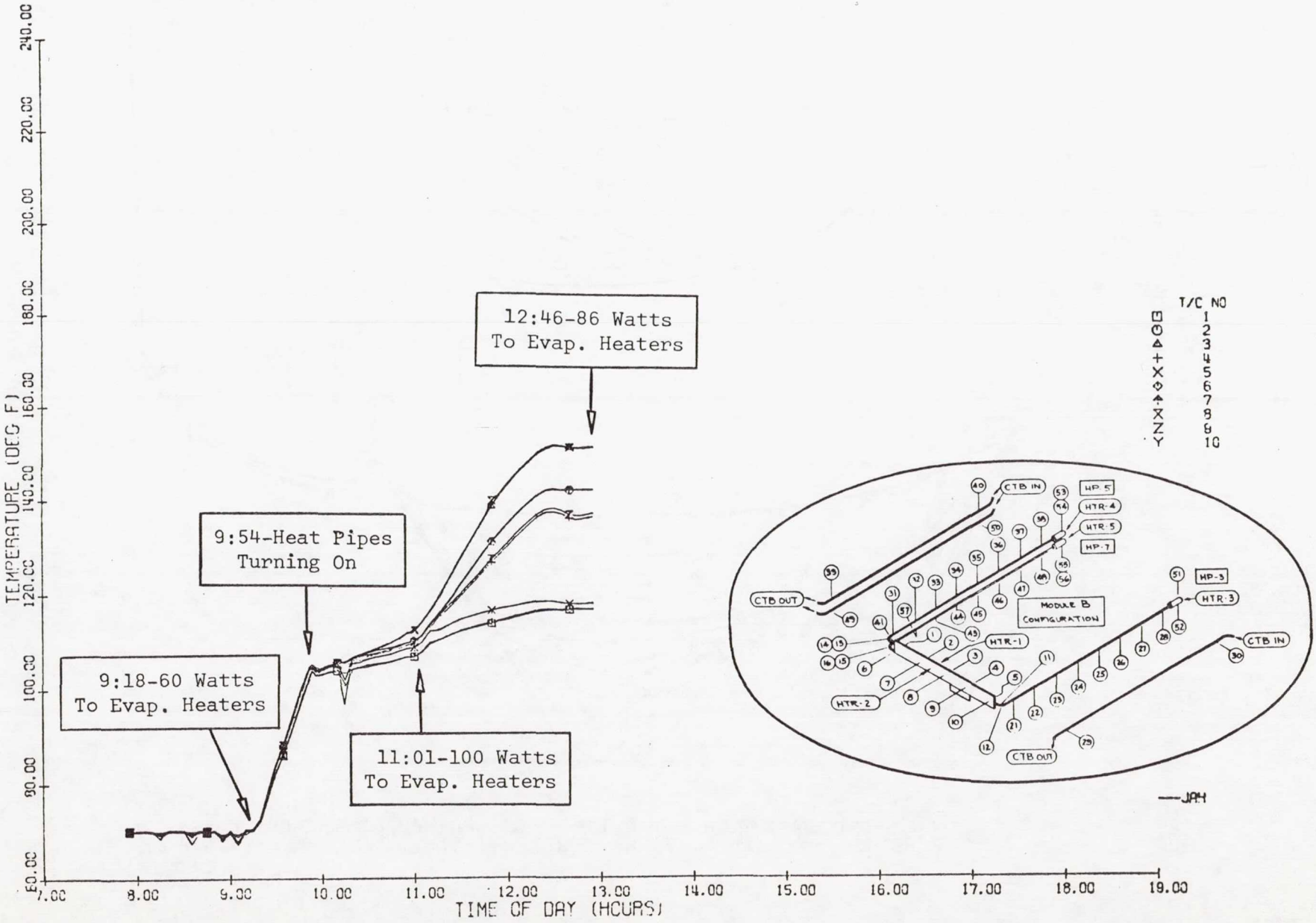


FIGURE A-5.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179



06

FIGURE A-5.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

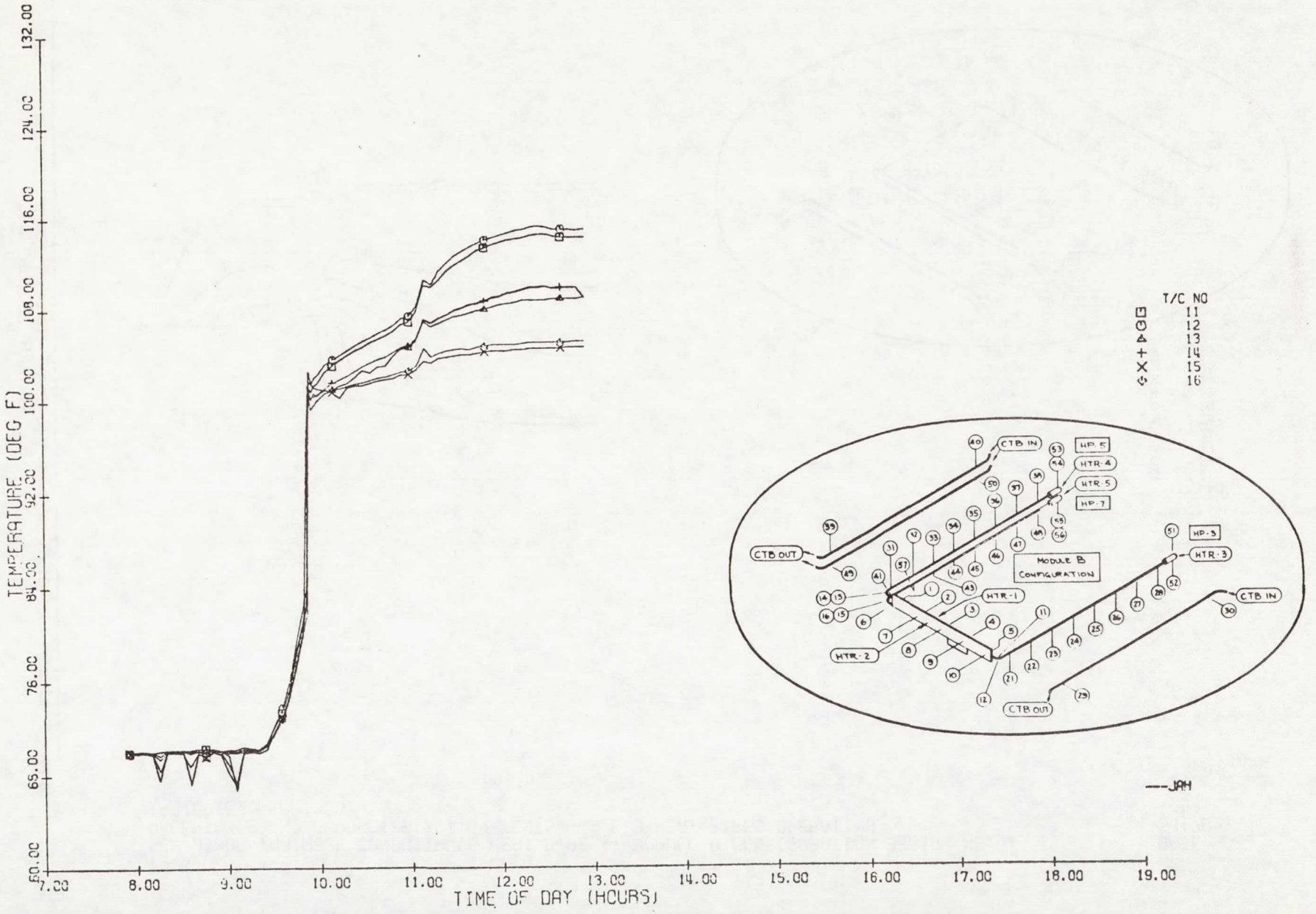


FIGURE A-5.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

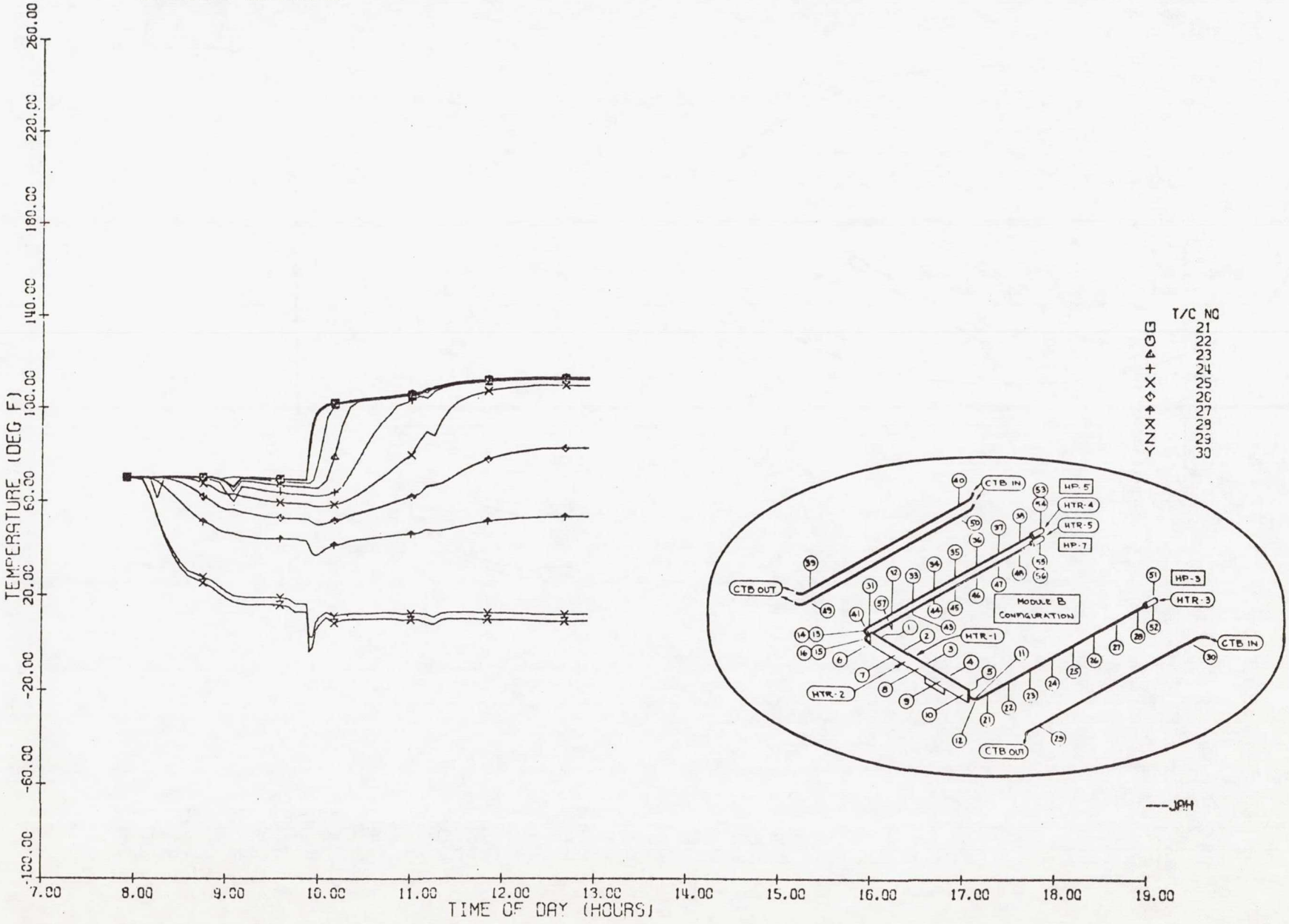


FIGURE A-5.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE 53179

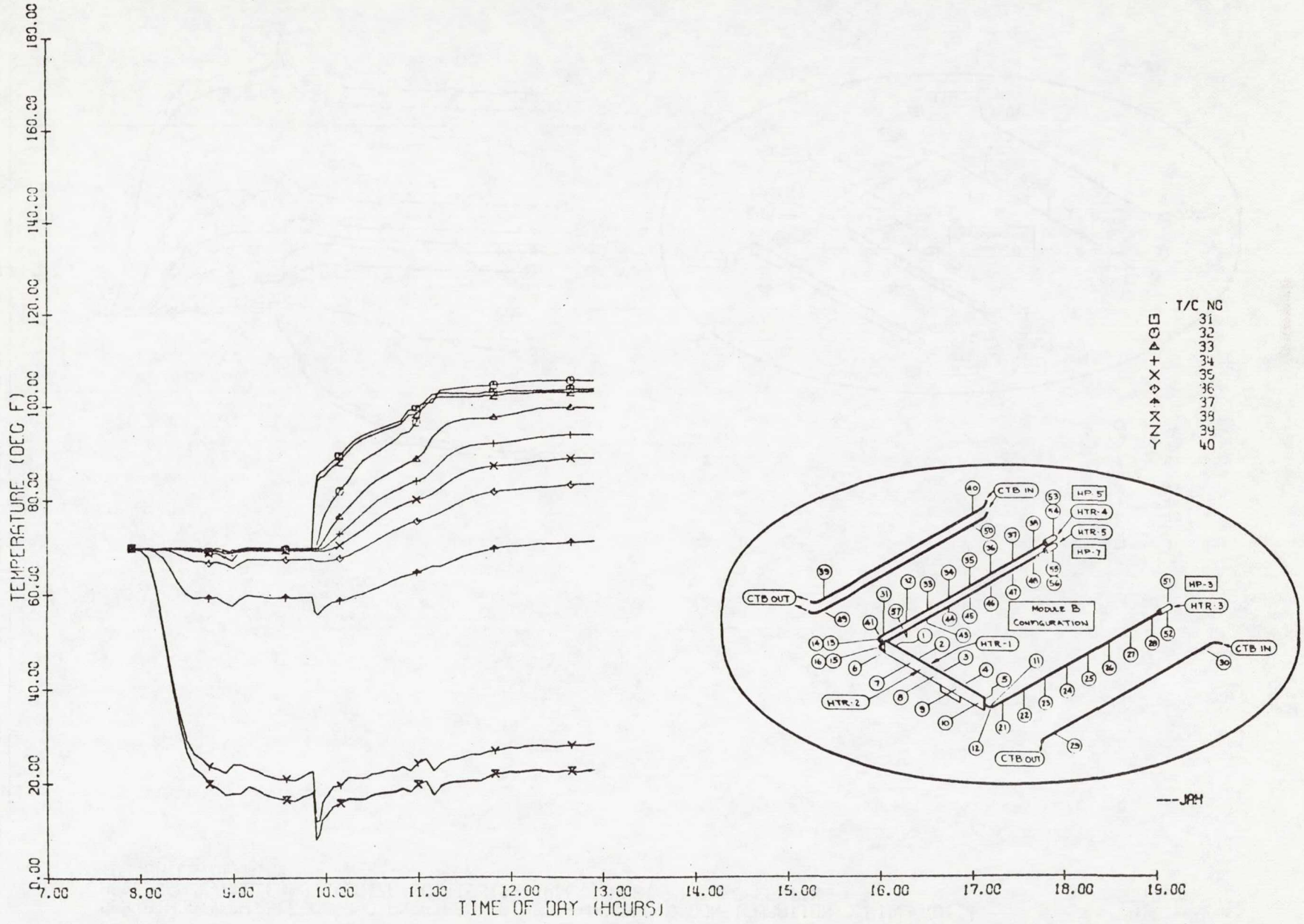


FIGURE A-5.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

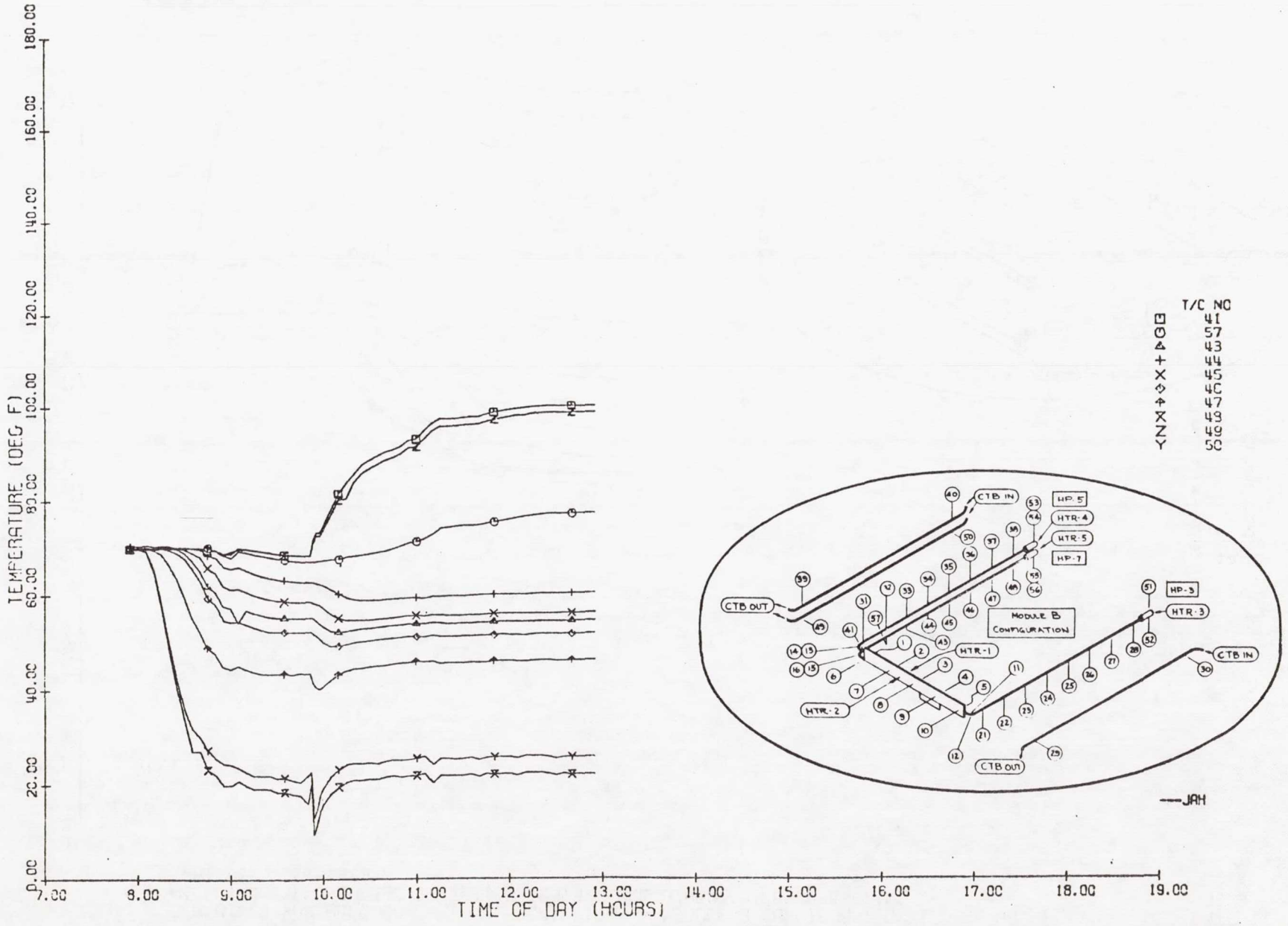


FIGURE A-5.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

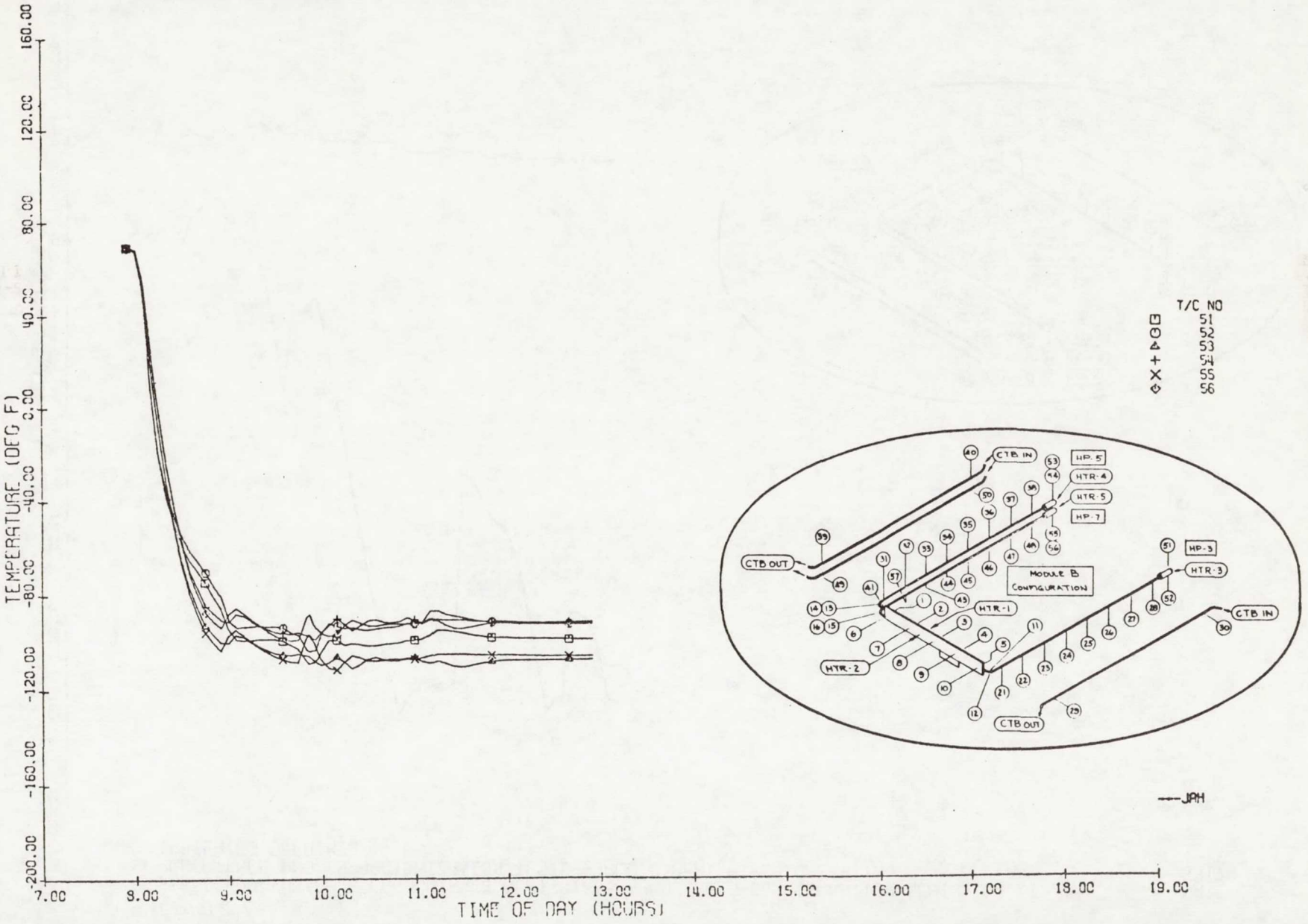


FIGURE A-5.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

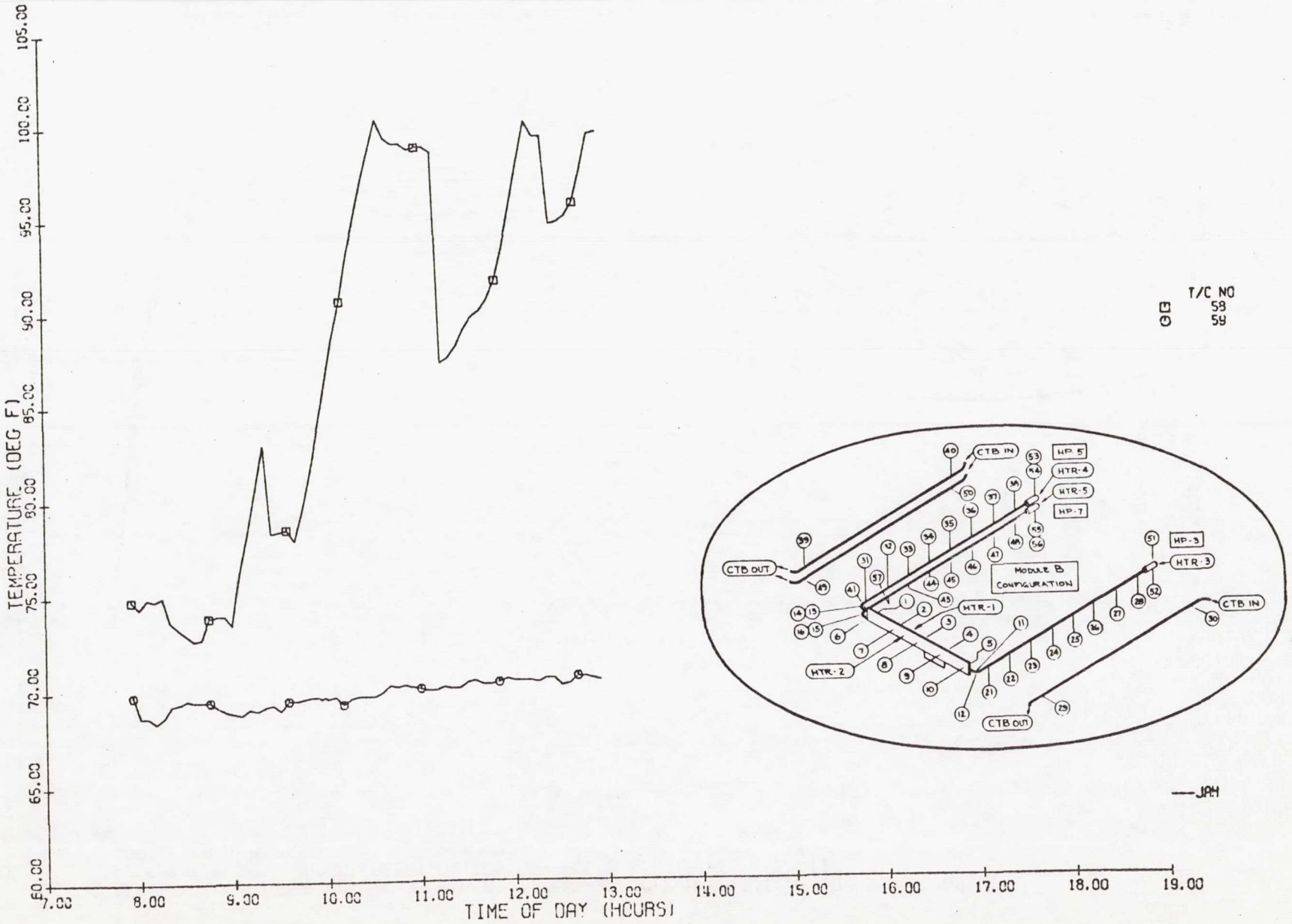


FIGURE A-5.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
53179

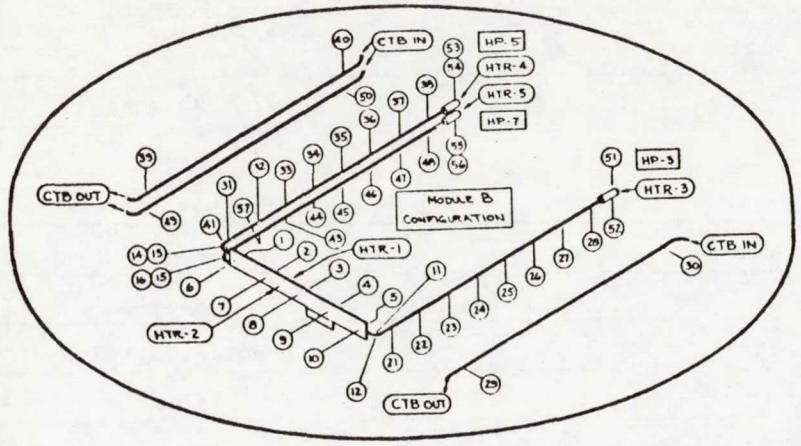


FIGURE A-5.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 53179 TIME = 958
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

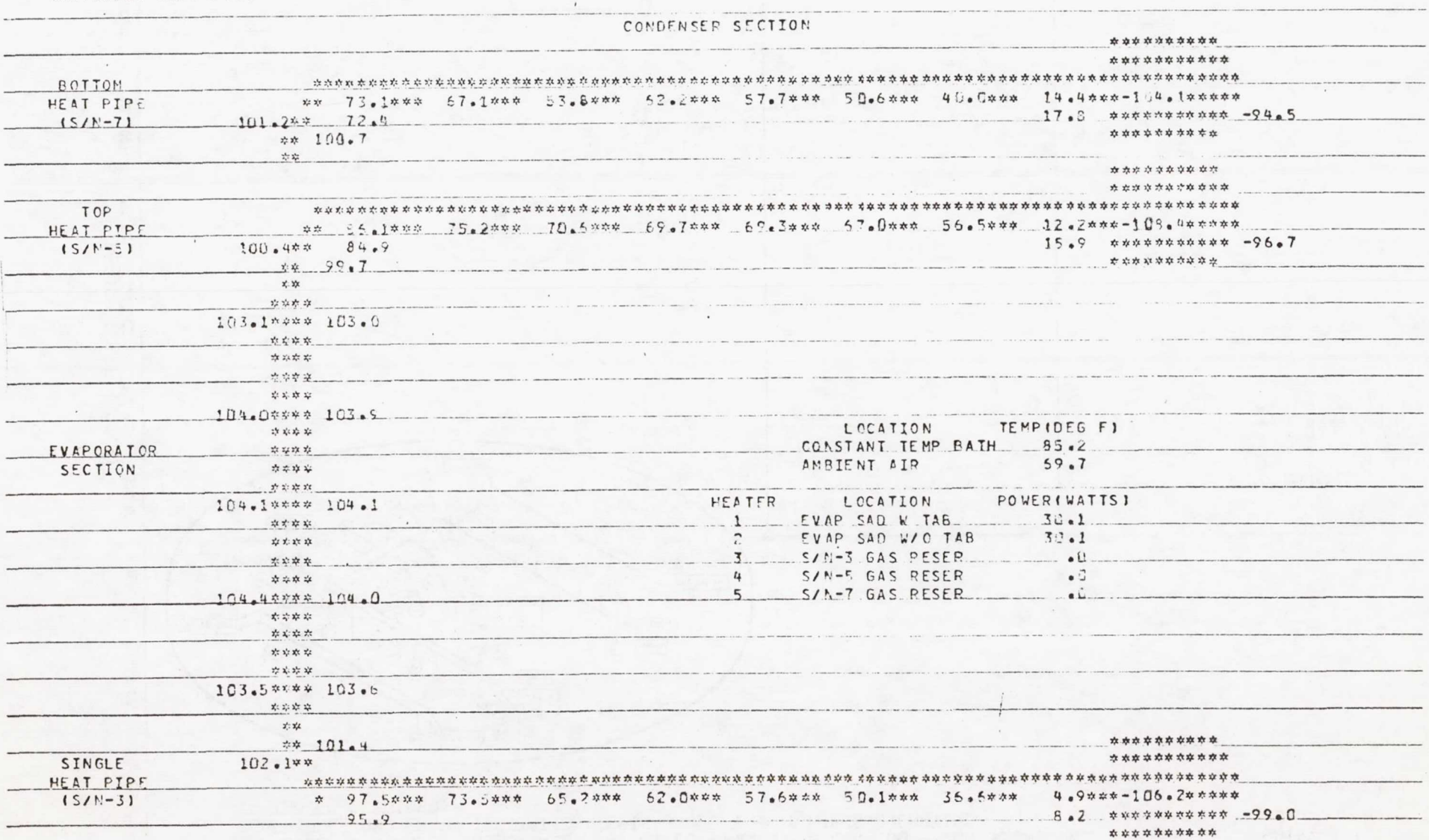


FIGURE A-5.12

SEP PIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 53179 TIME = 1105
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

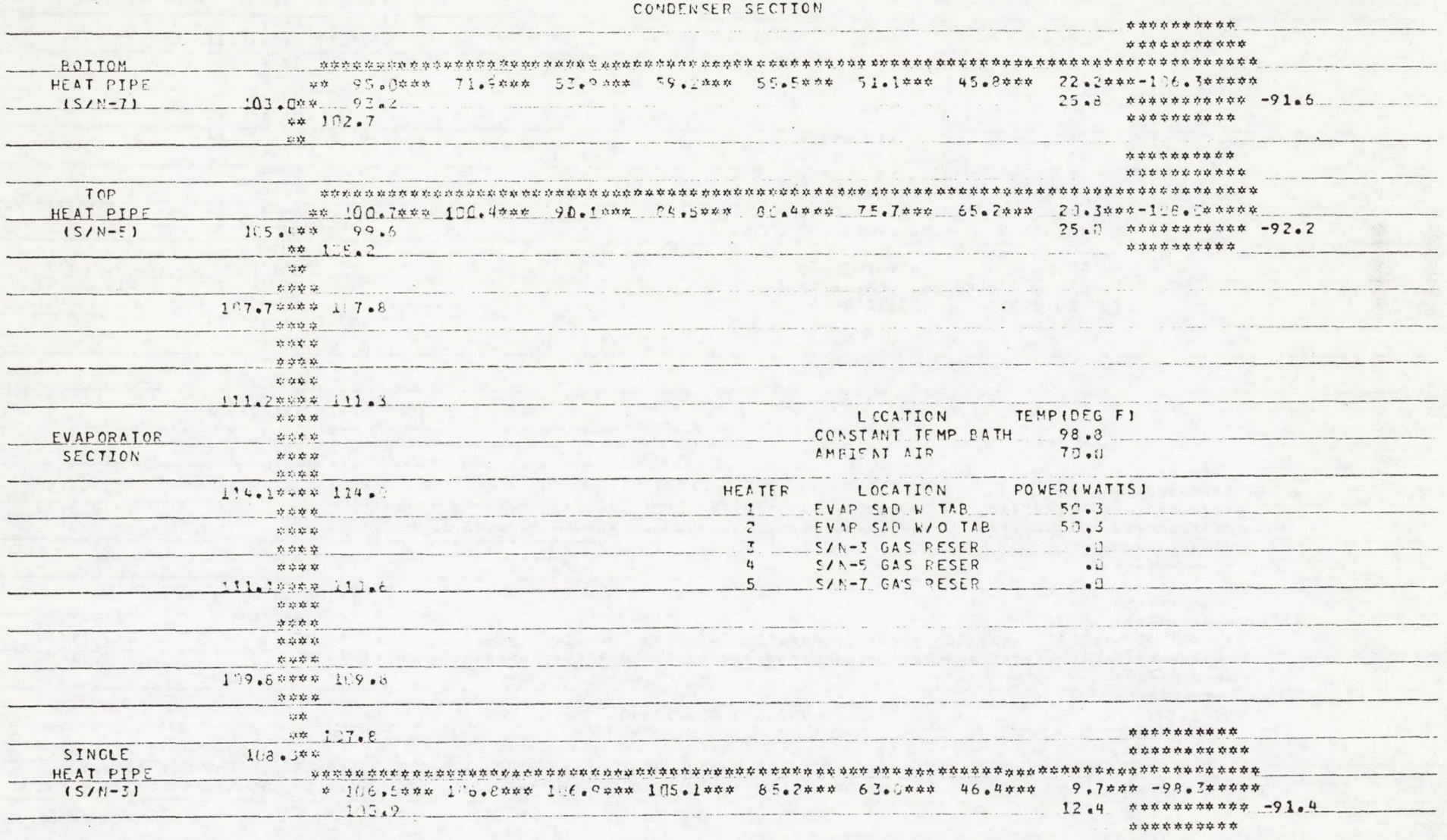


FIGURE A-5.13

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 53179 TIME = 1205
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

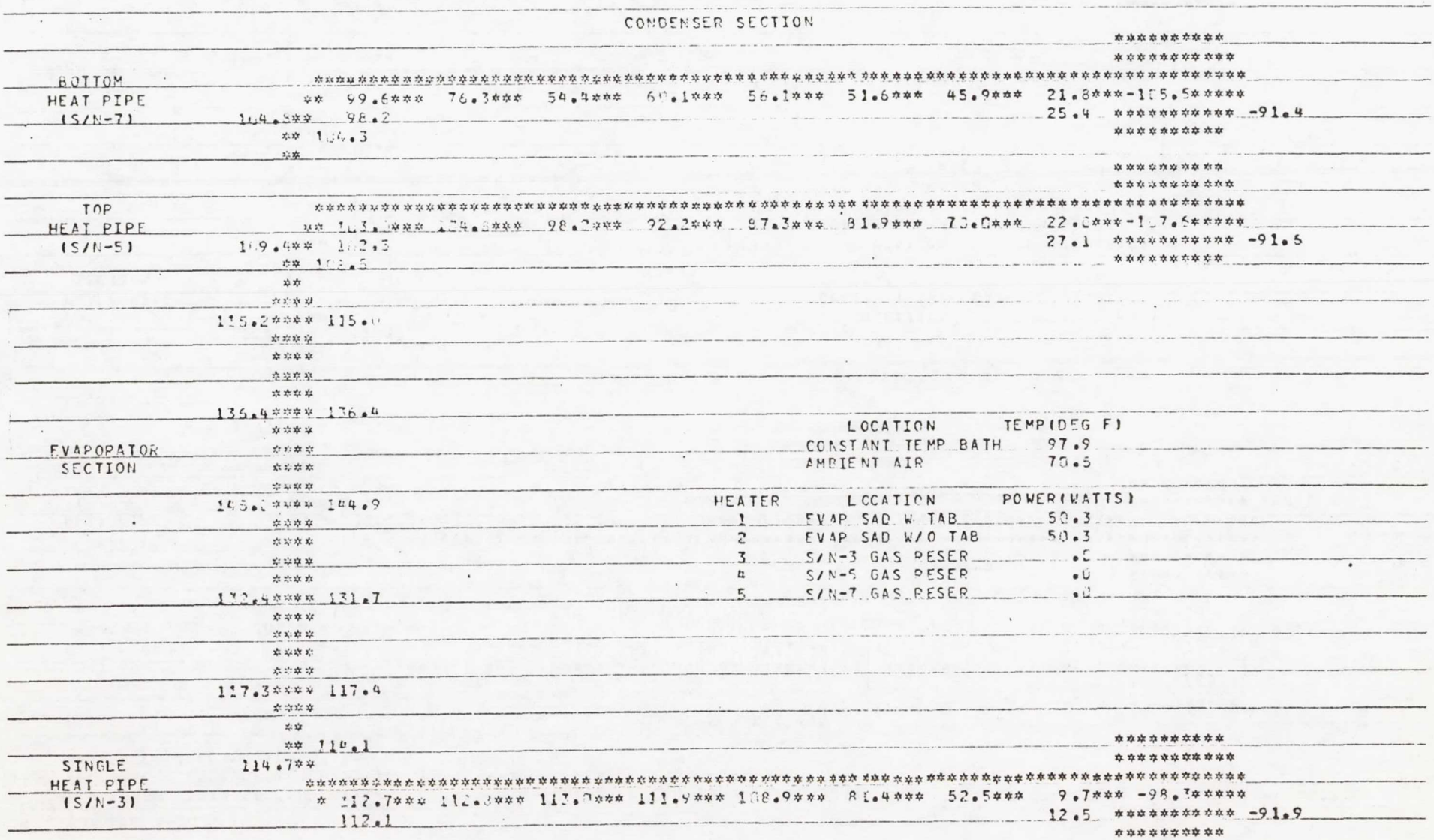


FIGURE A-5.14

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE B CONFIGURATION SERIAL NO. 1 TEST DATE = 53179 TIME = 1245
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

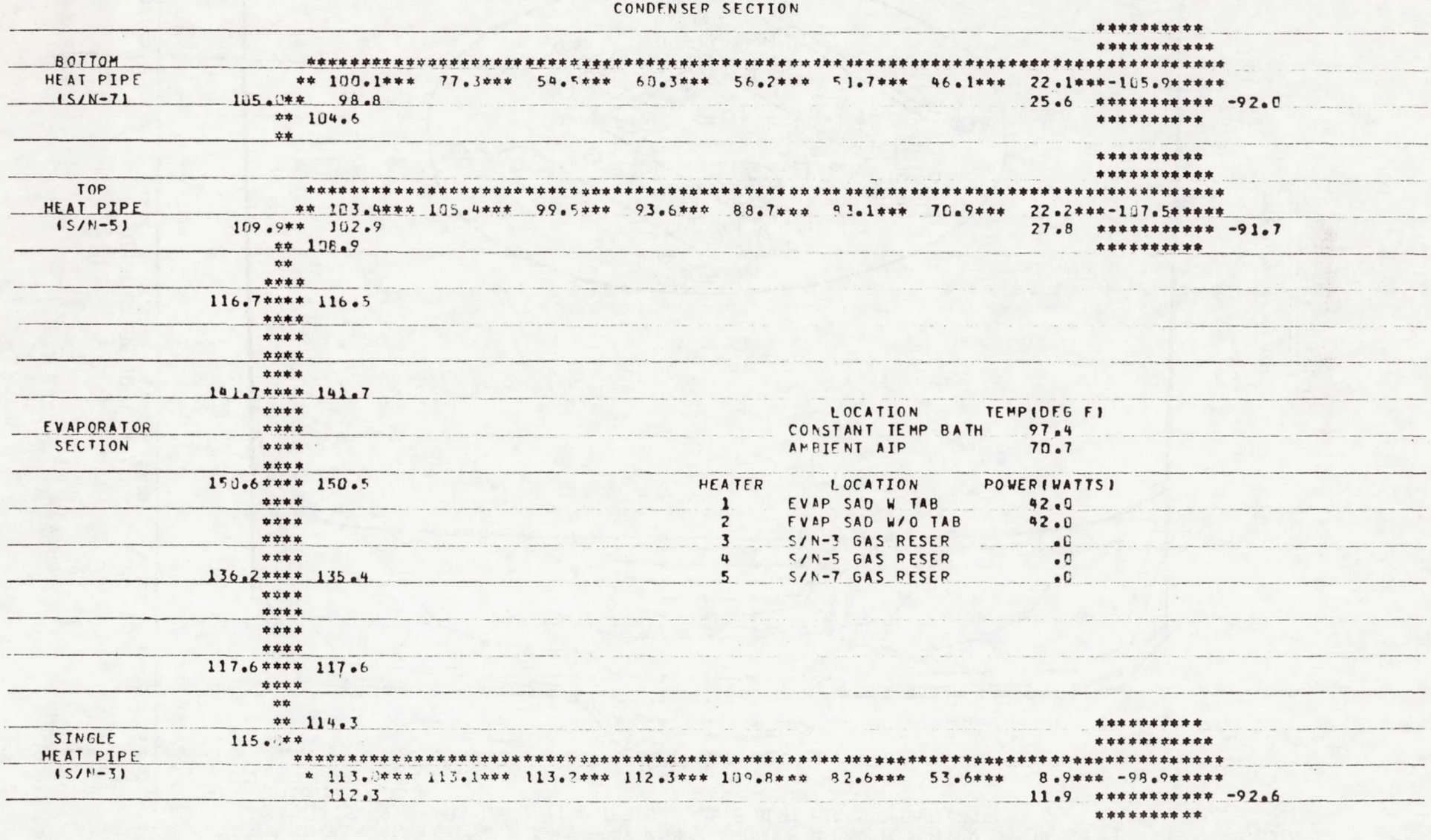


FIGURE A-6.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

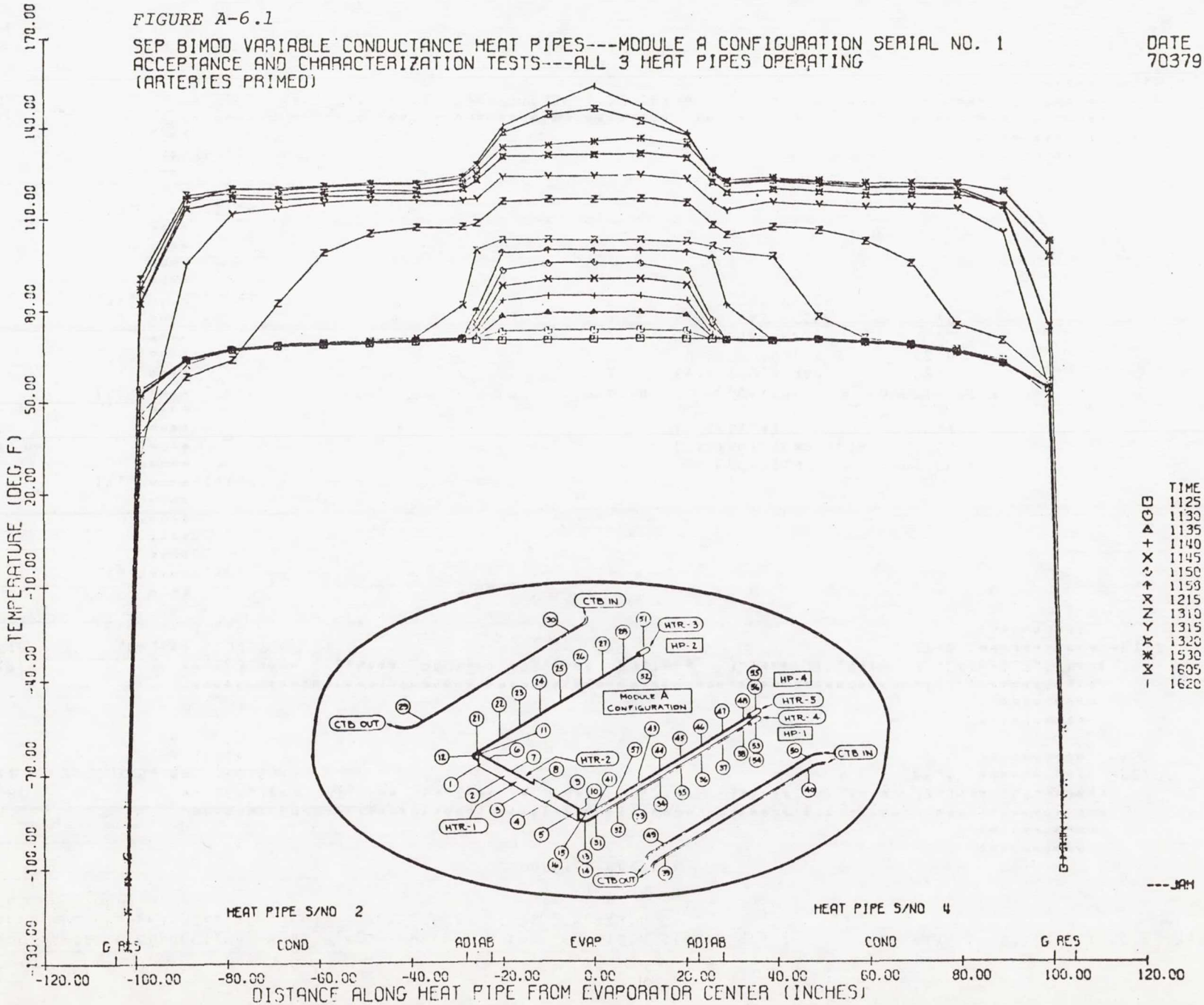


FIGURE A-6.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

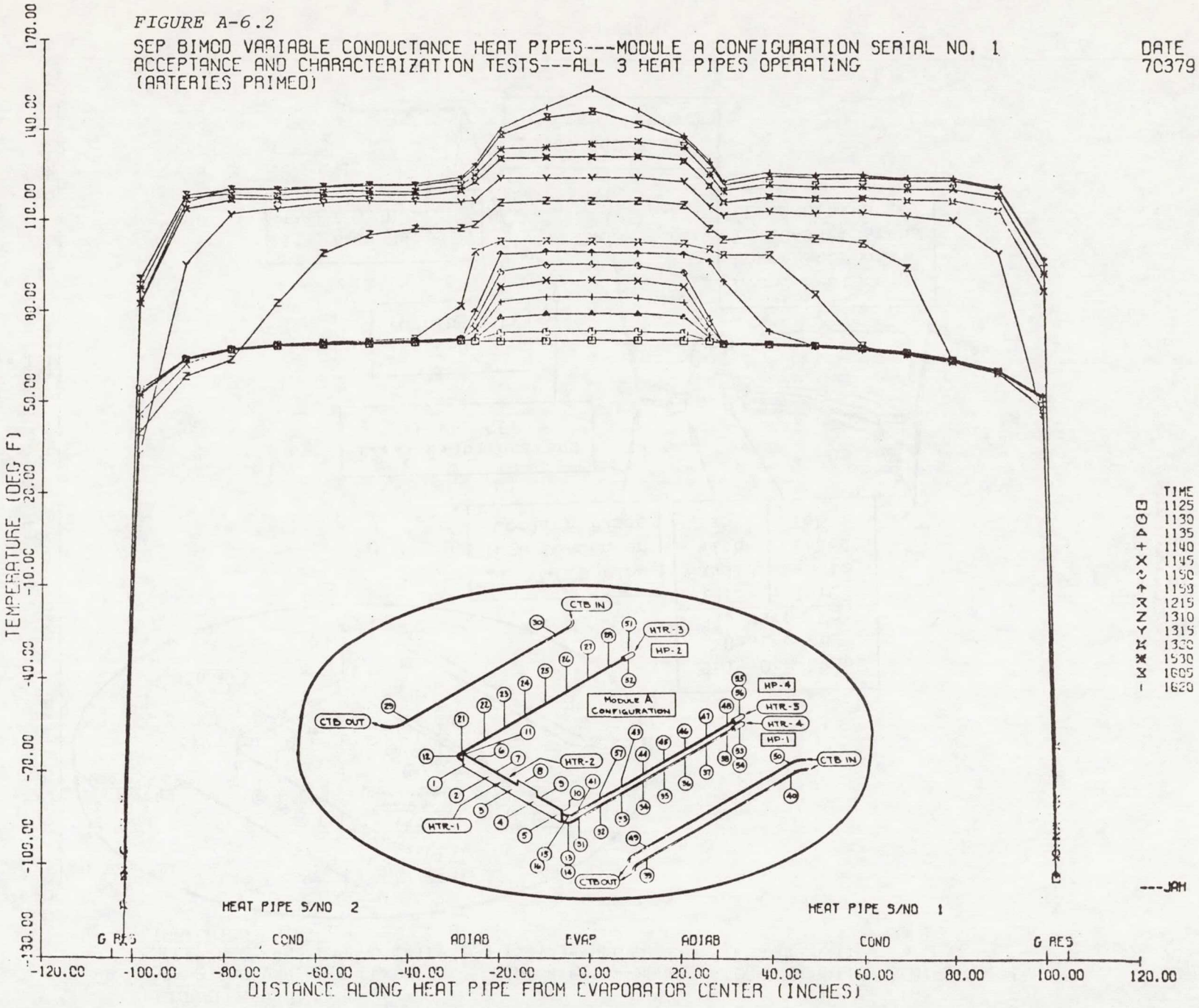


FIGURE A-6.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

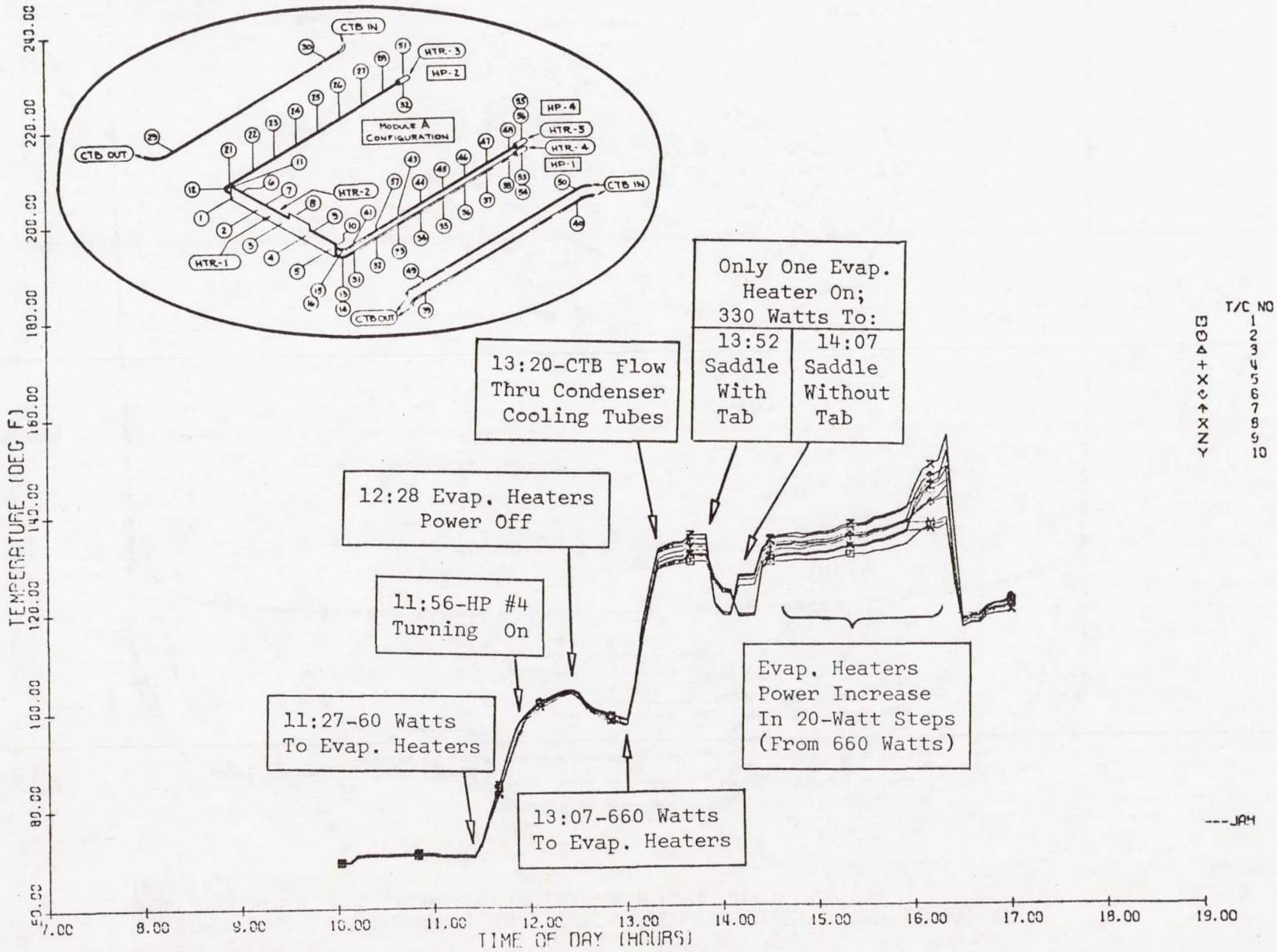


FIGURE A-6.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

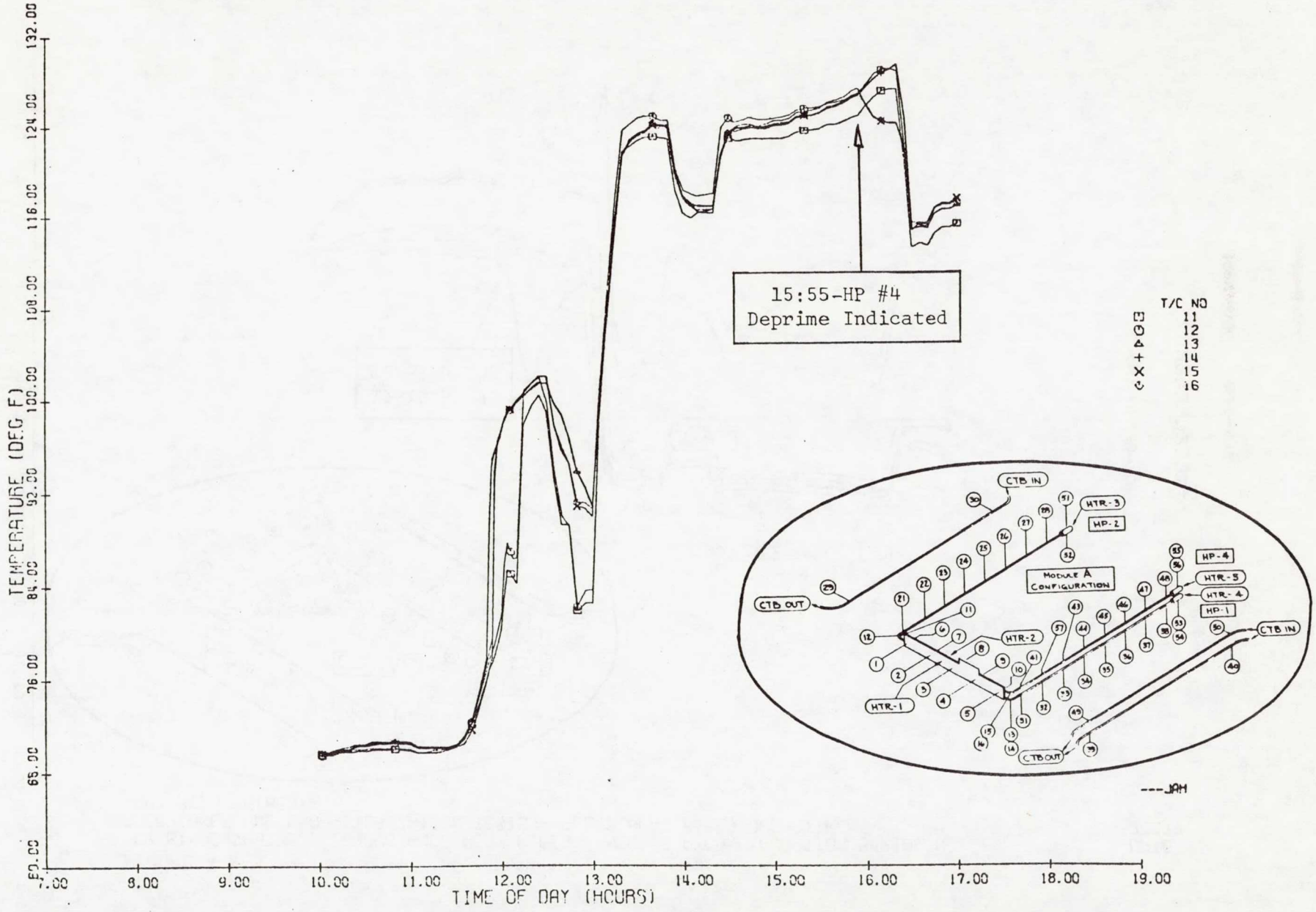


FIGURE A-6.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

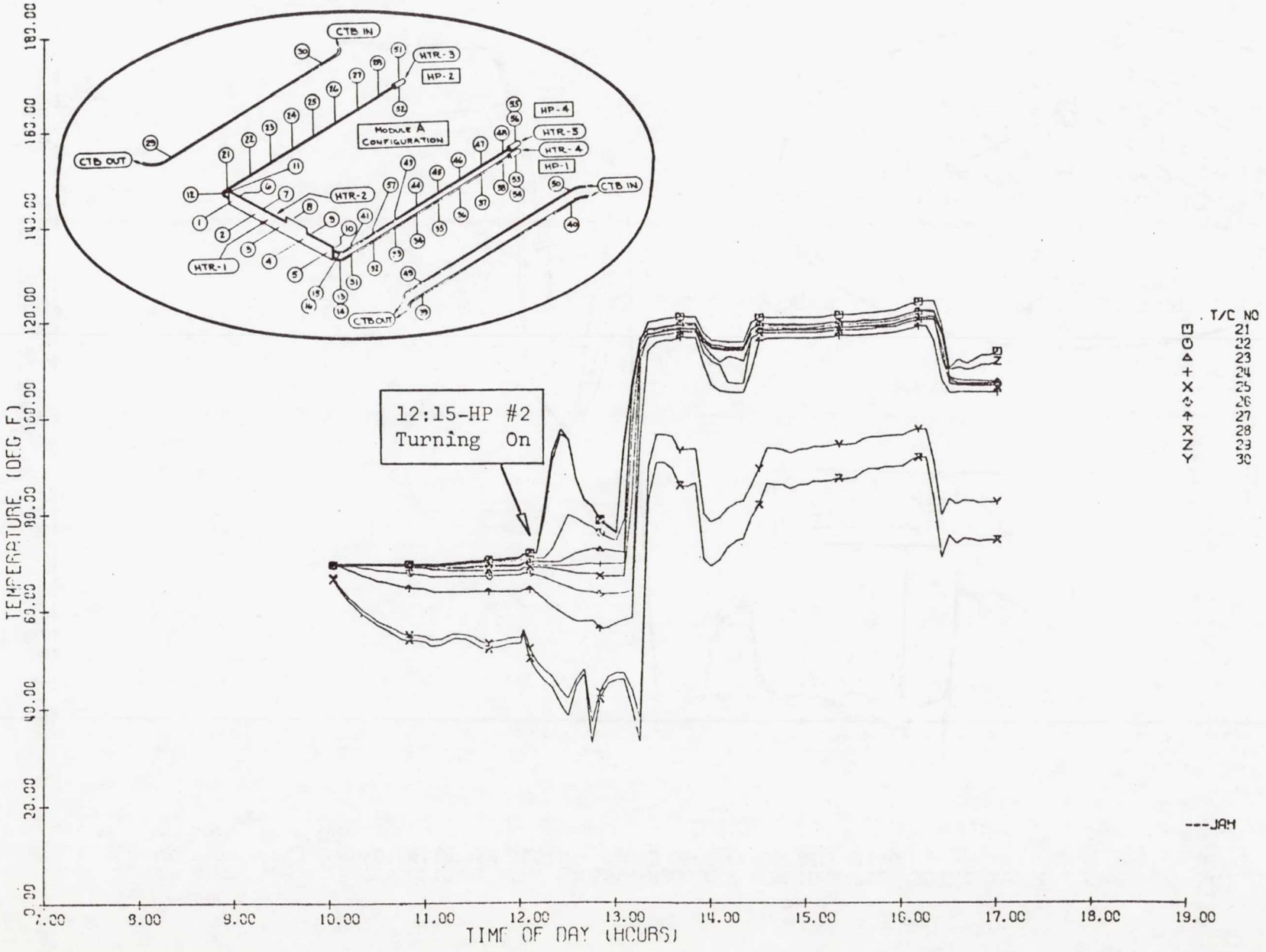


FIGURE A-6.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

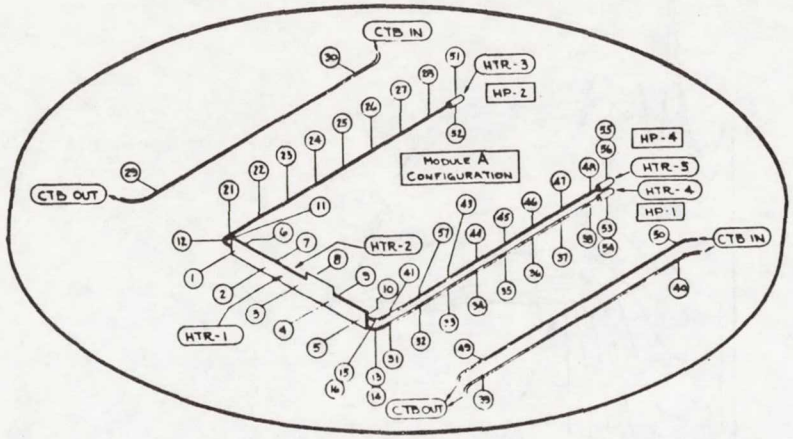


FIGURE A-6.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

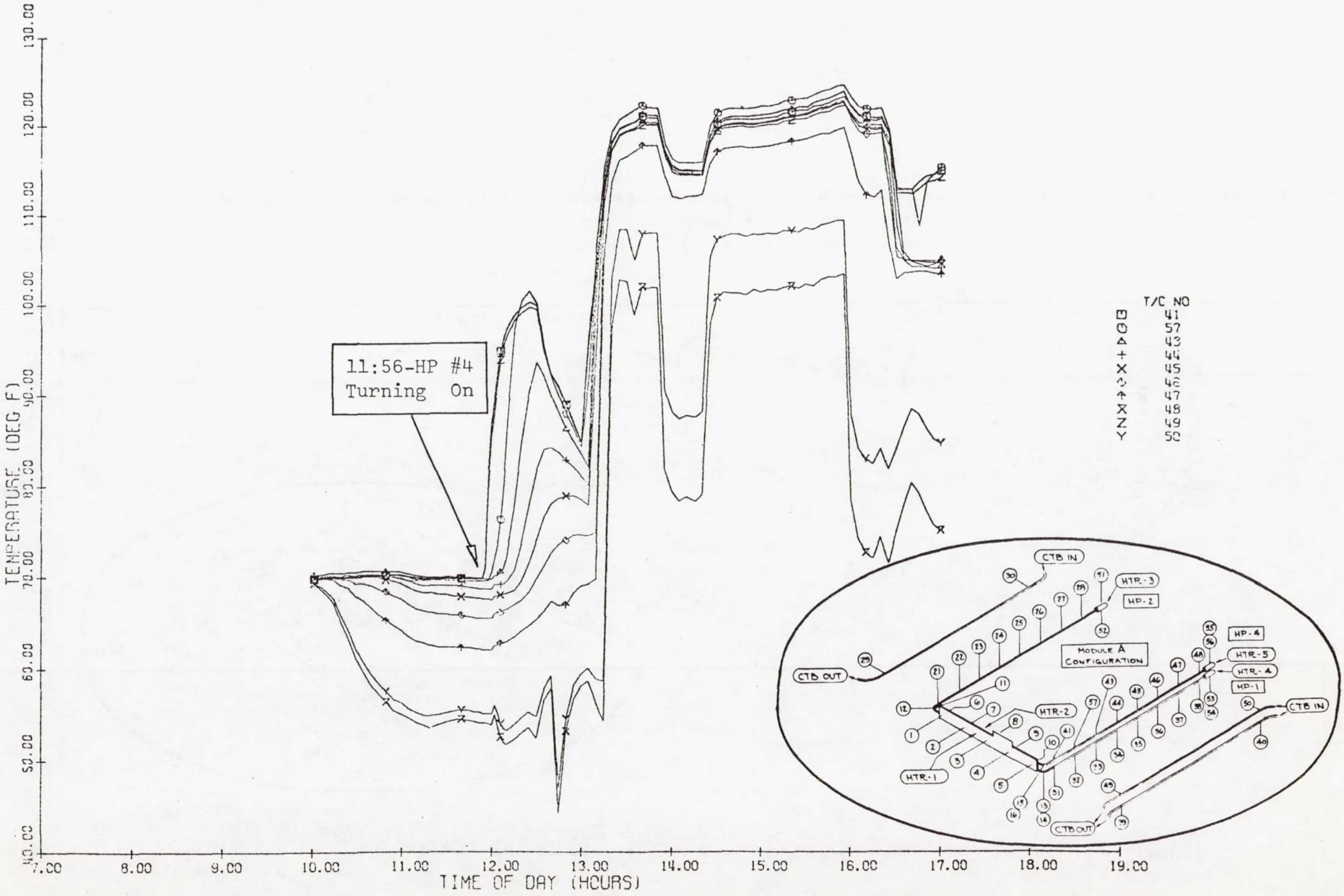


FIGURE A-6.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

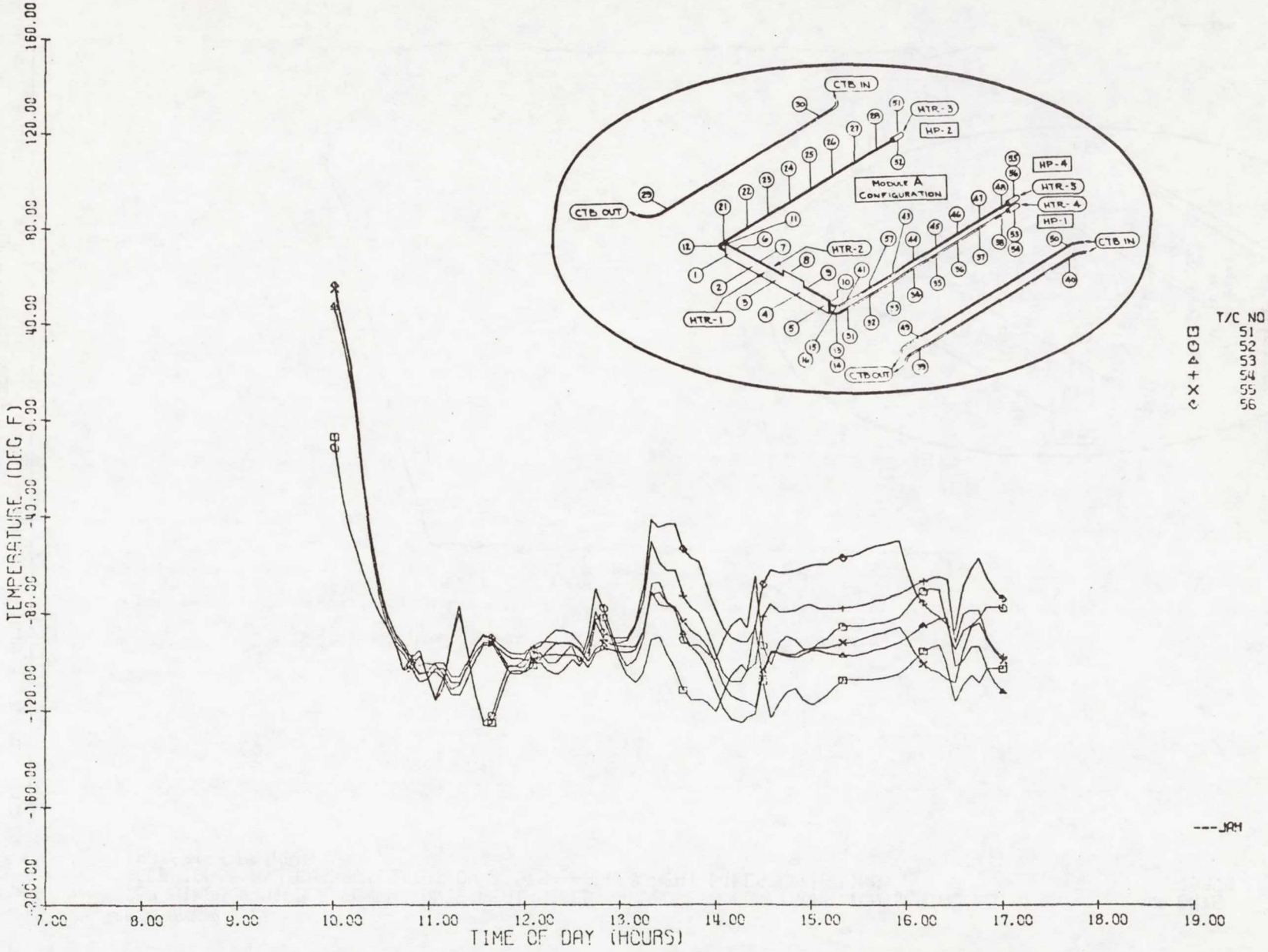


FIGURE A-6.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED)

DATE 70379

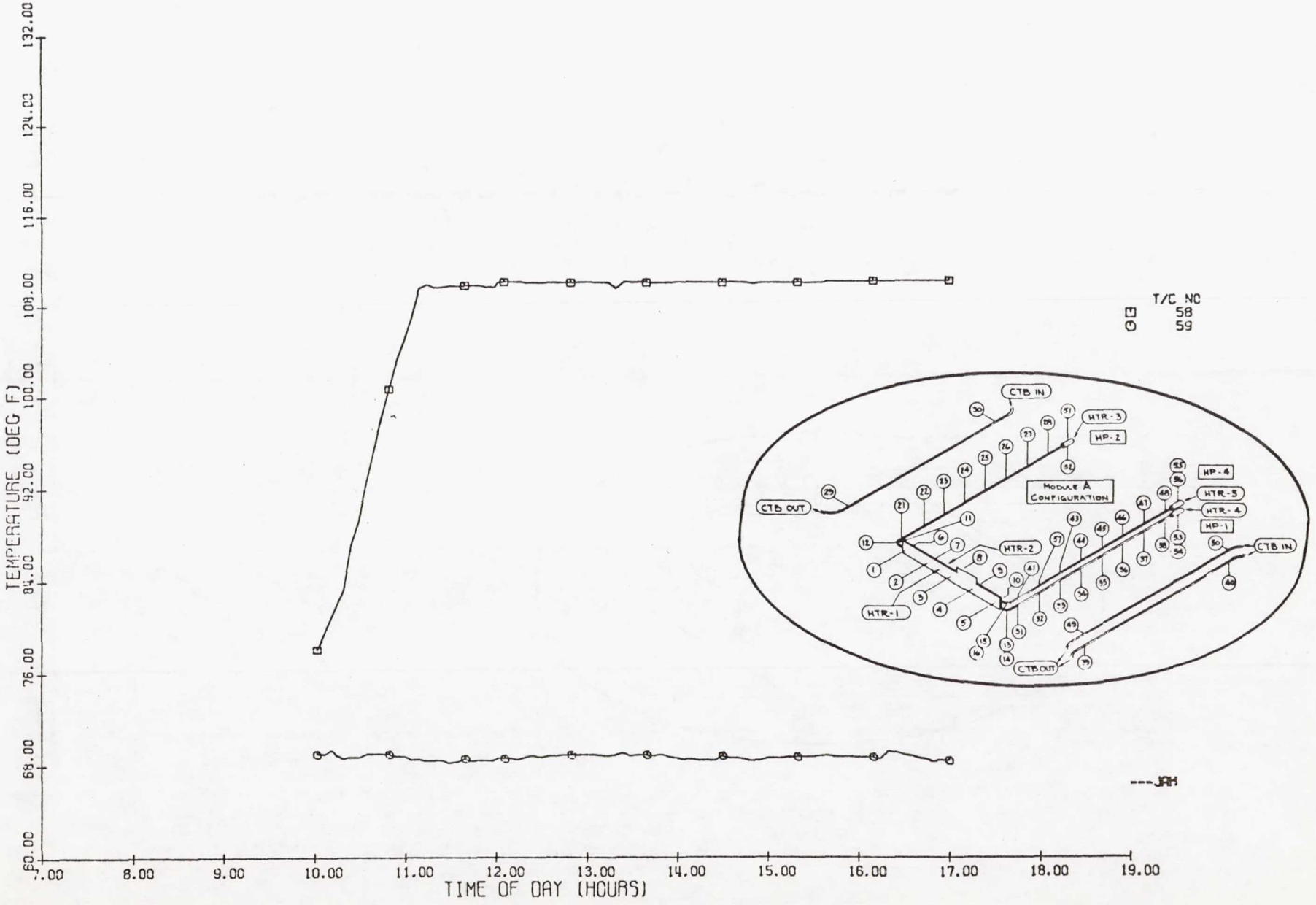


FIGURE A-6.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

DATE
70379

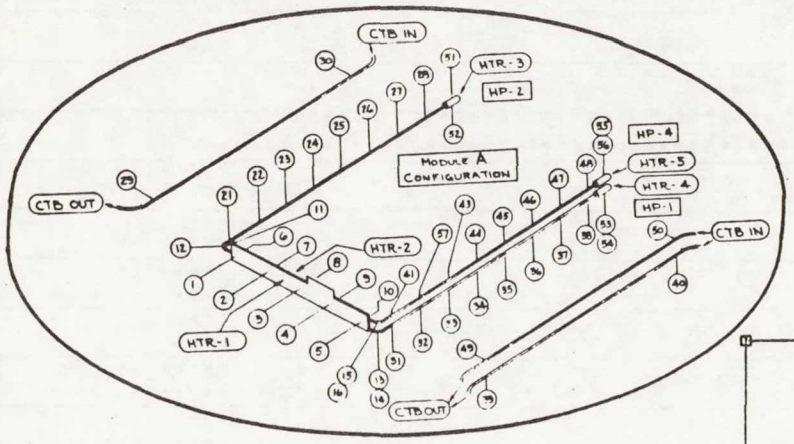


FIGURE A-6.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 70379 TIME = 1200
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

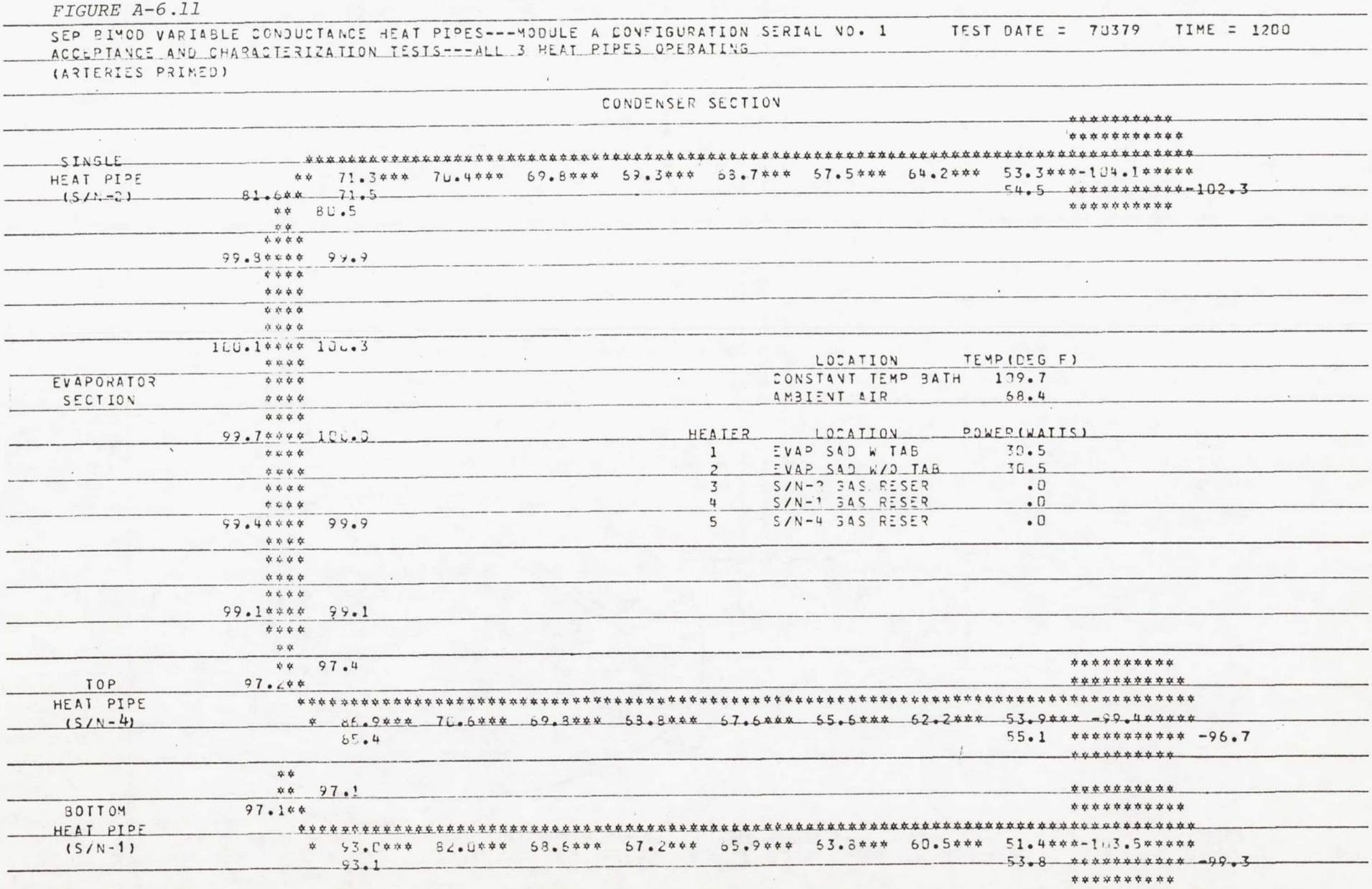


FIGURE A-6.12

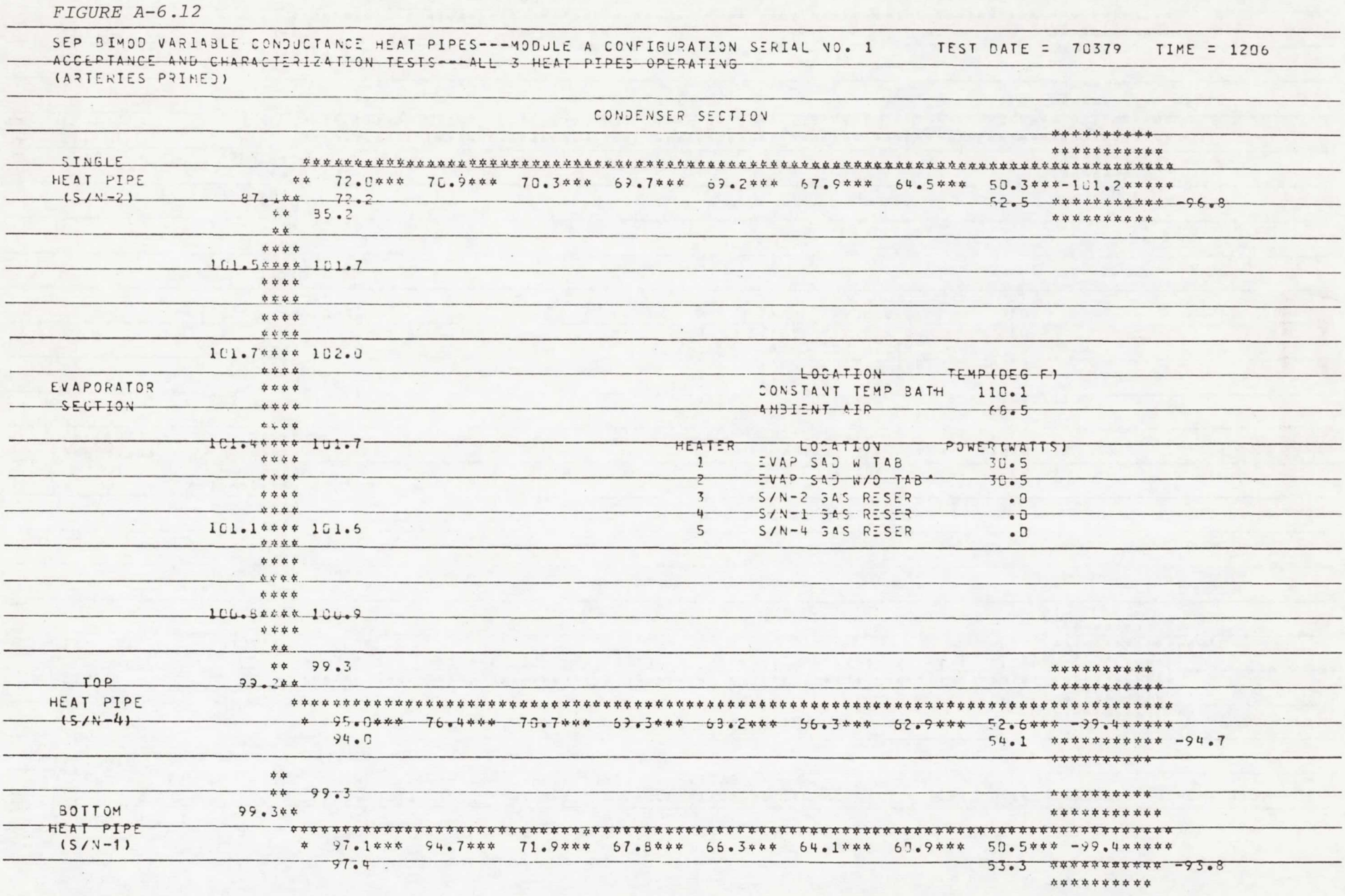

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 70379 TIME = 1206
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)
CONDENSER SECTION
SINGLE HEAT PIPE (S/N-2)
87.1 72.2 72.0 70.9 70.3 69.7 69.2 67.9 64.5 50.3 -101.2
85.2
101.5 101.7
101.7 102.0
EVAPORATOR SECTION
101.4 101.7
101.1 101.6
100.8 100.9
LOCATION TEMP(DEG F)
CONSTANT TEMP BATH 110.1
AMBIENT AIR 66.5
HEATER LOCATION POWER(WATTS)
1 EVAP SAD W TAB 30.5
2 EVAP SAD W/O TAB 30.5
3 S/N-2 GAS RESER .0
4 S/N-1 GAS RESER .0
5 S/N-4 GAS RESER .0
TOP HEAT PIPE (S/N-4)
99.2 99.3
95.0 76.4 70.7 69.3 63.2 56.3 62.9 52.6 -99.4
94.0 54.1 -94.7
BOTTOM HEAT PIPE (S/N-1)
99.3 99.3
97.1 94.7 71.9 67.8 66.3 64.1 60.9 50.5 -99.4
97.4 53.3 -93.8

FIGURE A-6.13

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 70379 TIME = 1225
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

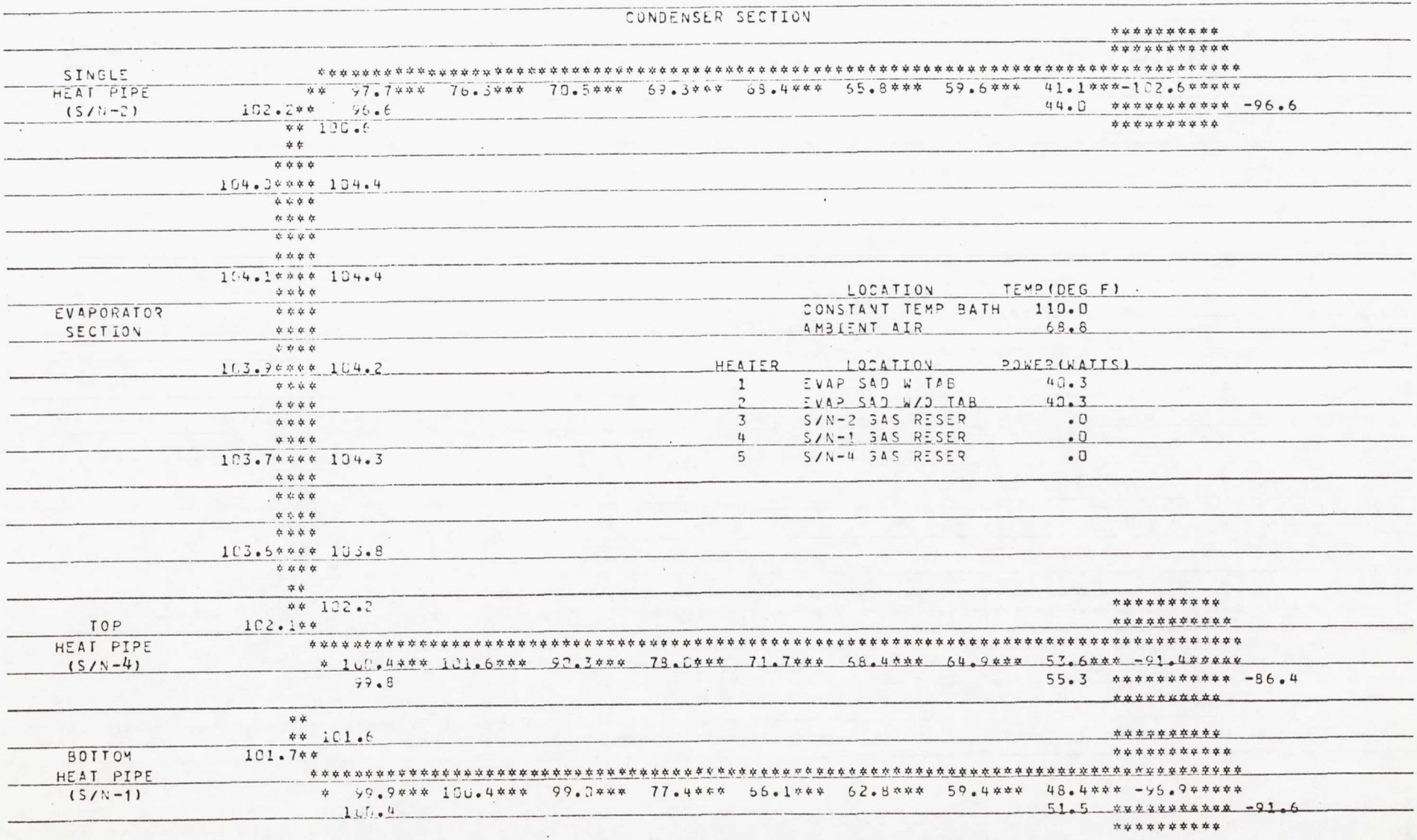


FIGURE A-6.14

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 70379 TIME = 1450
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)

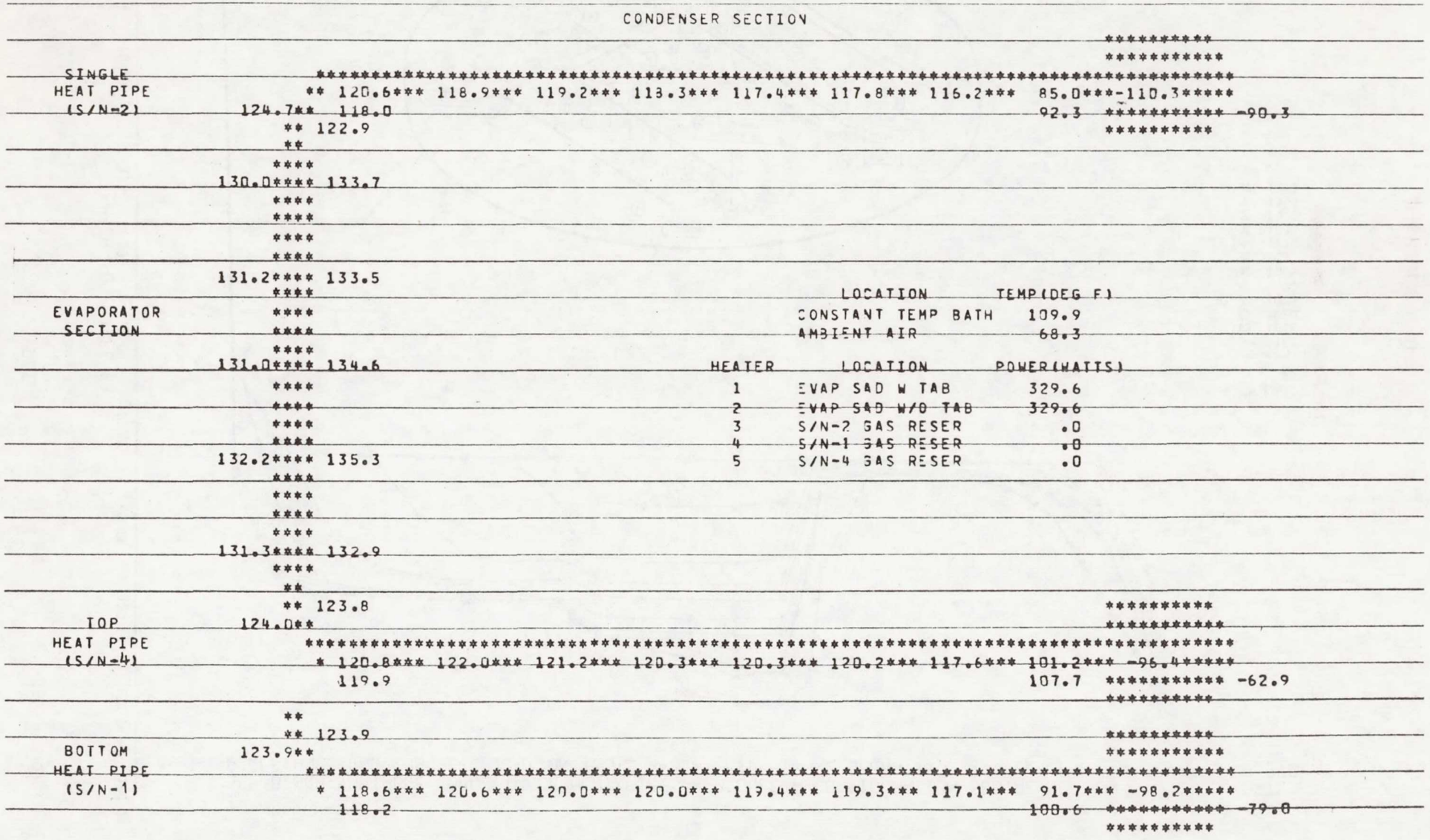


FIGURE A-7.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

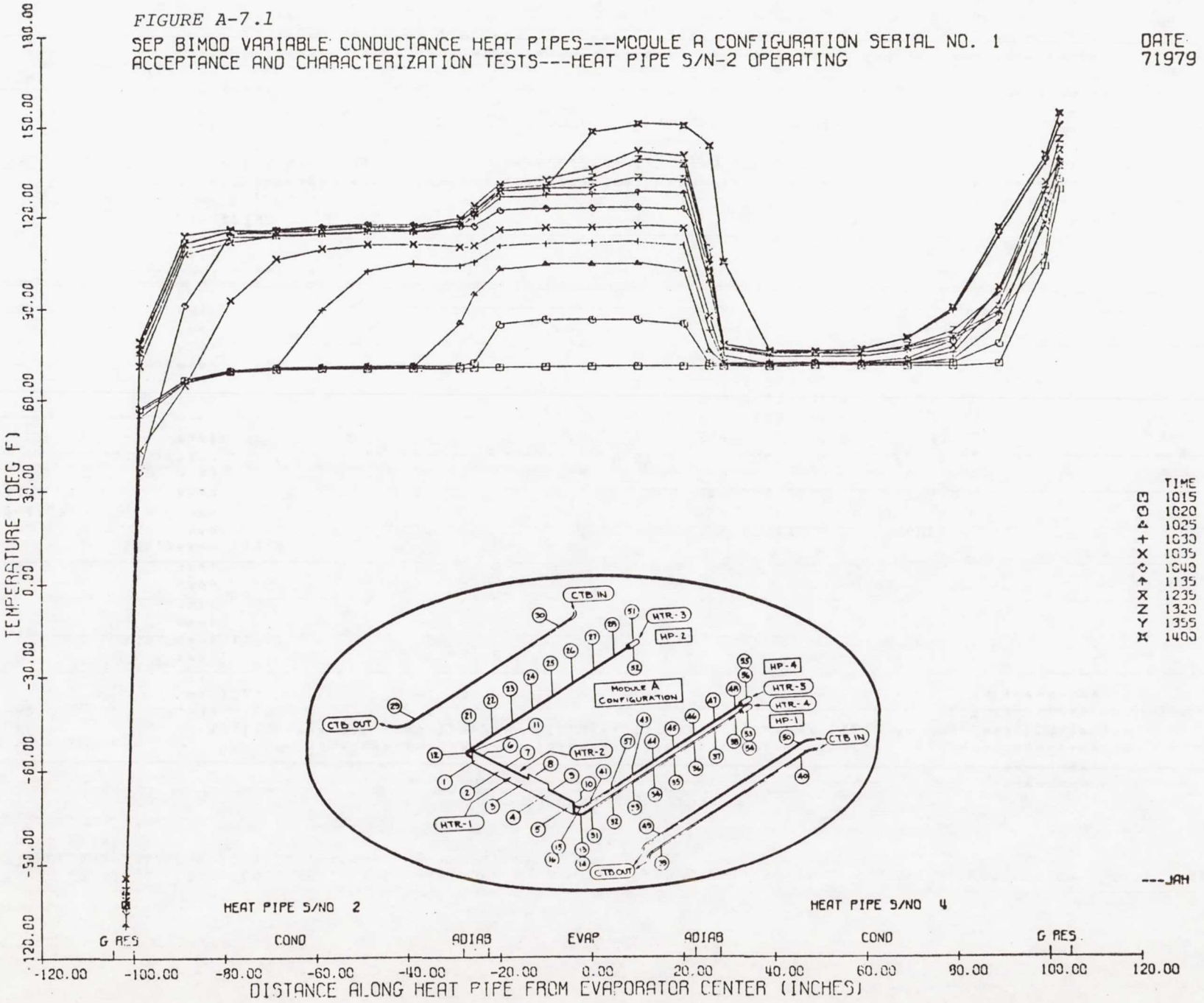


FIGURE A-7.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

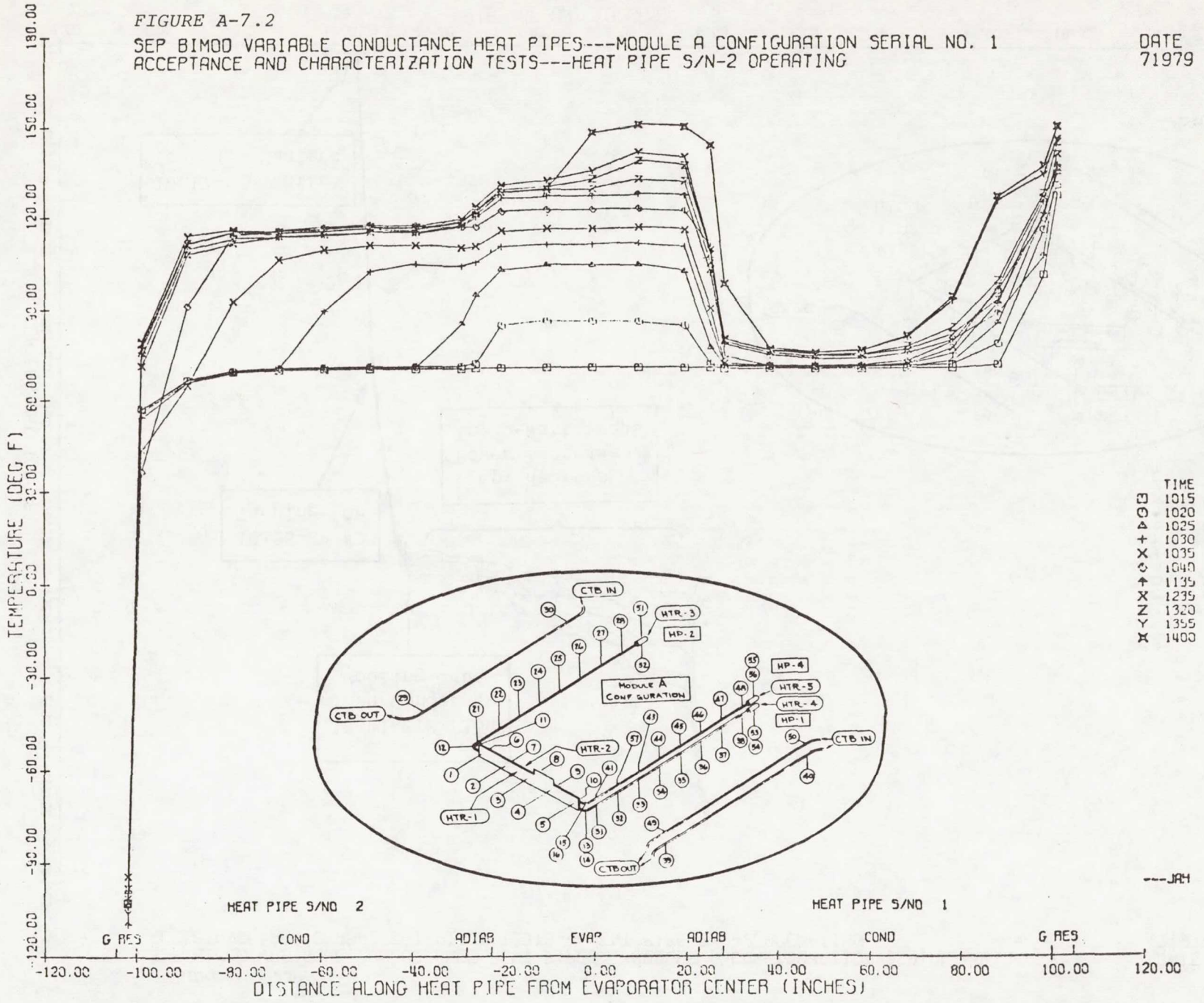


FIGURE A-7.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

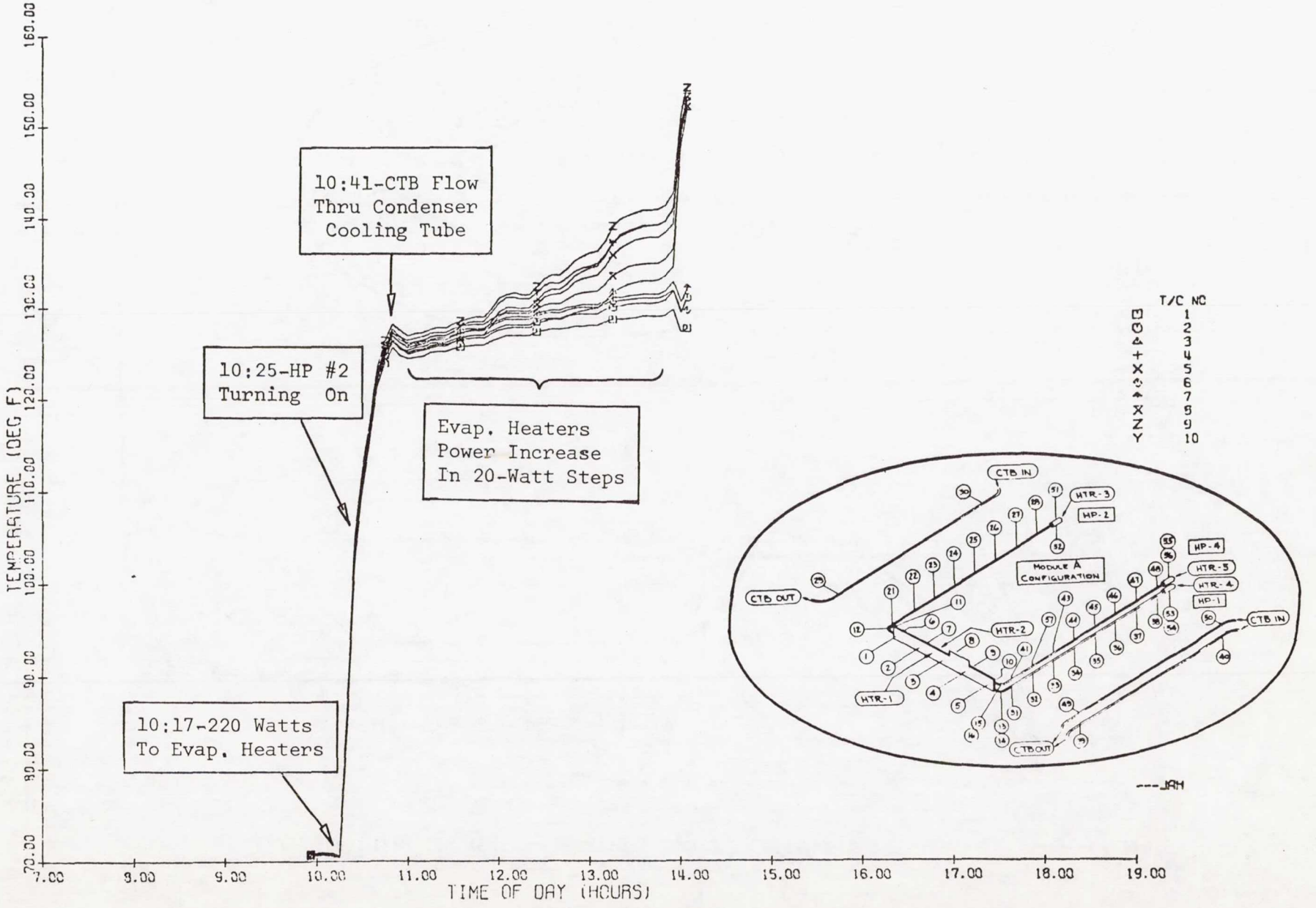


FIGURE A-7.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

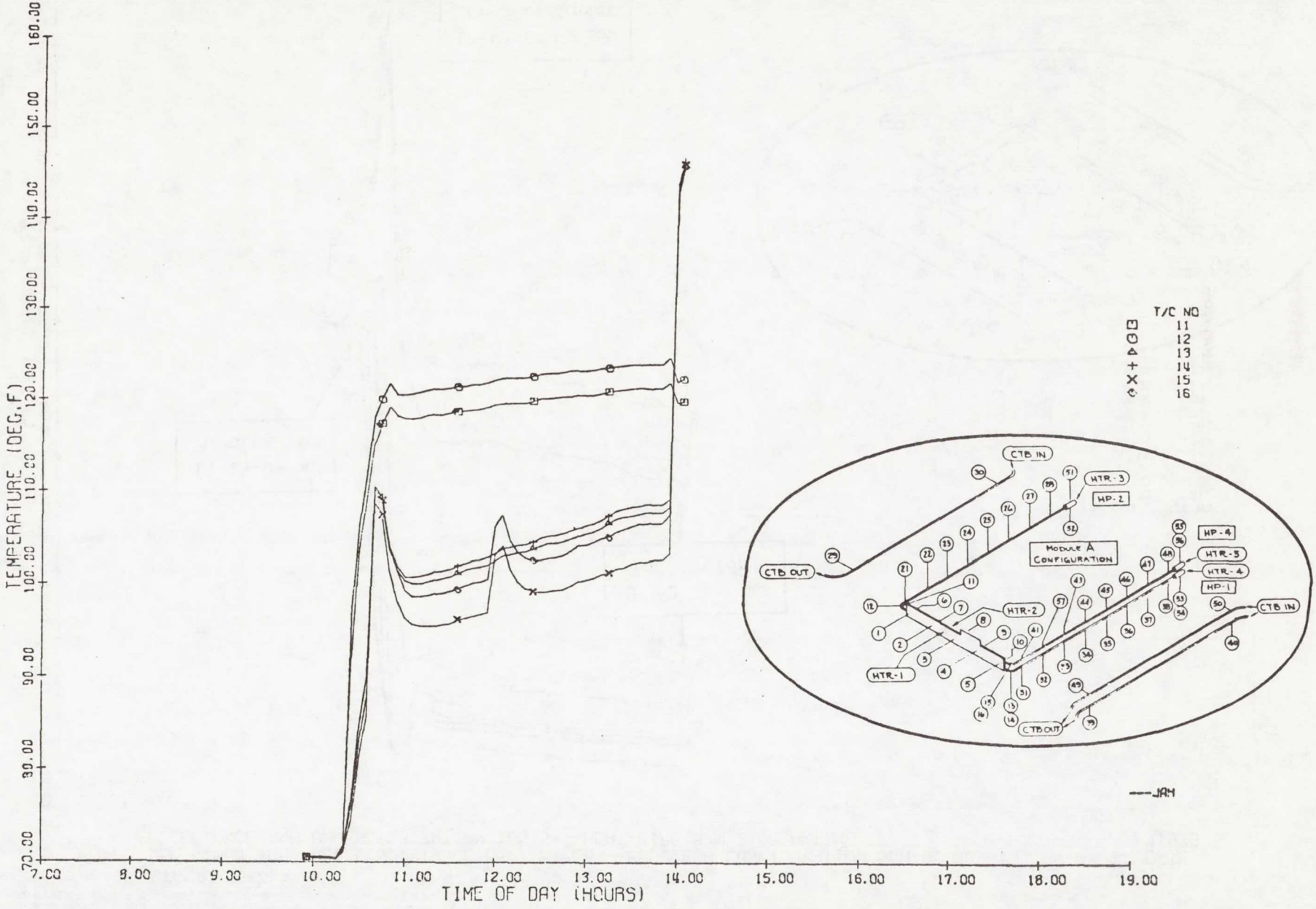


FIGURE A-7.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE 71979

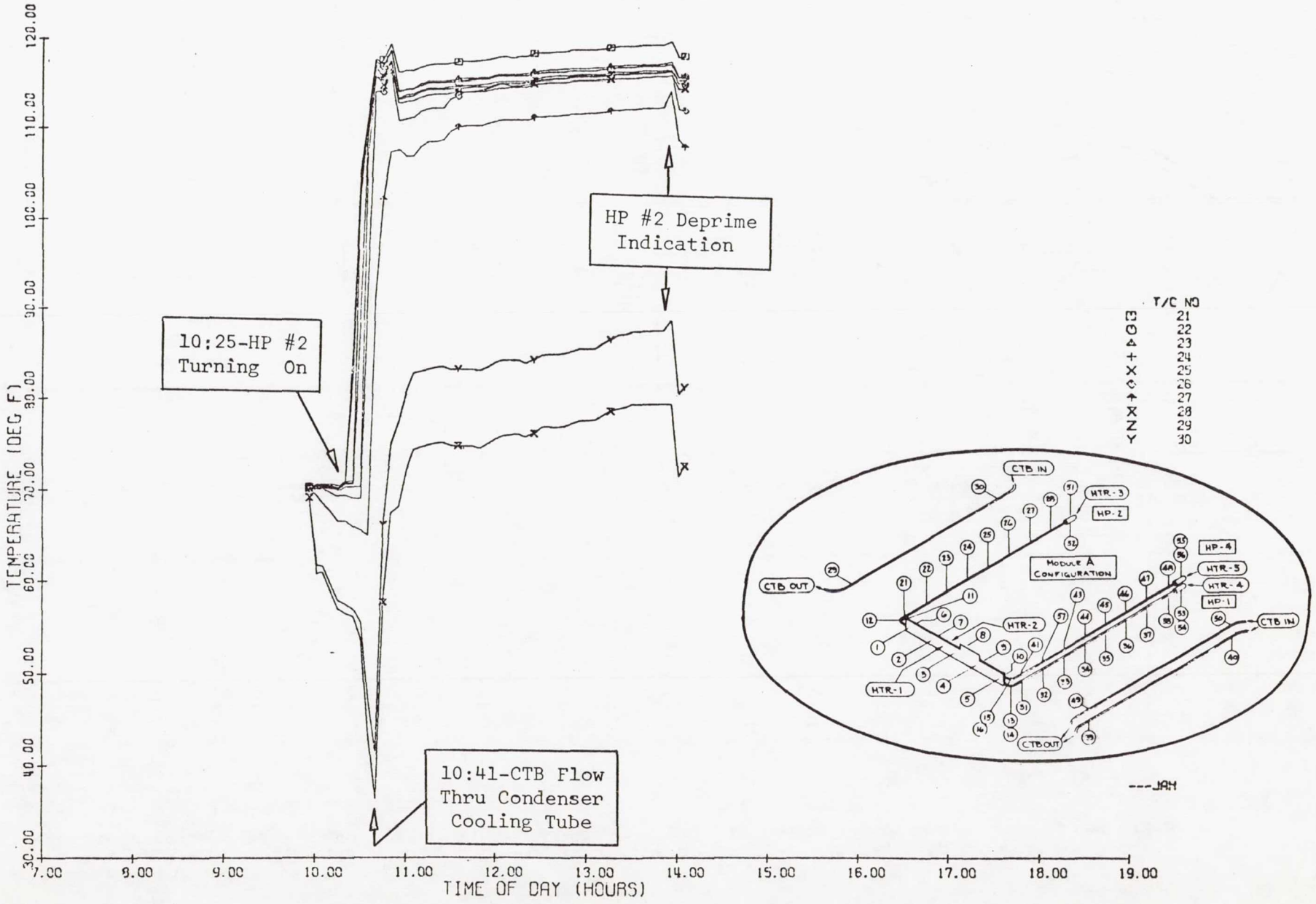


FIGURE A-7.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

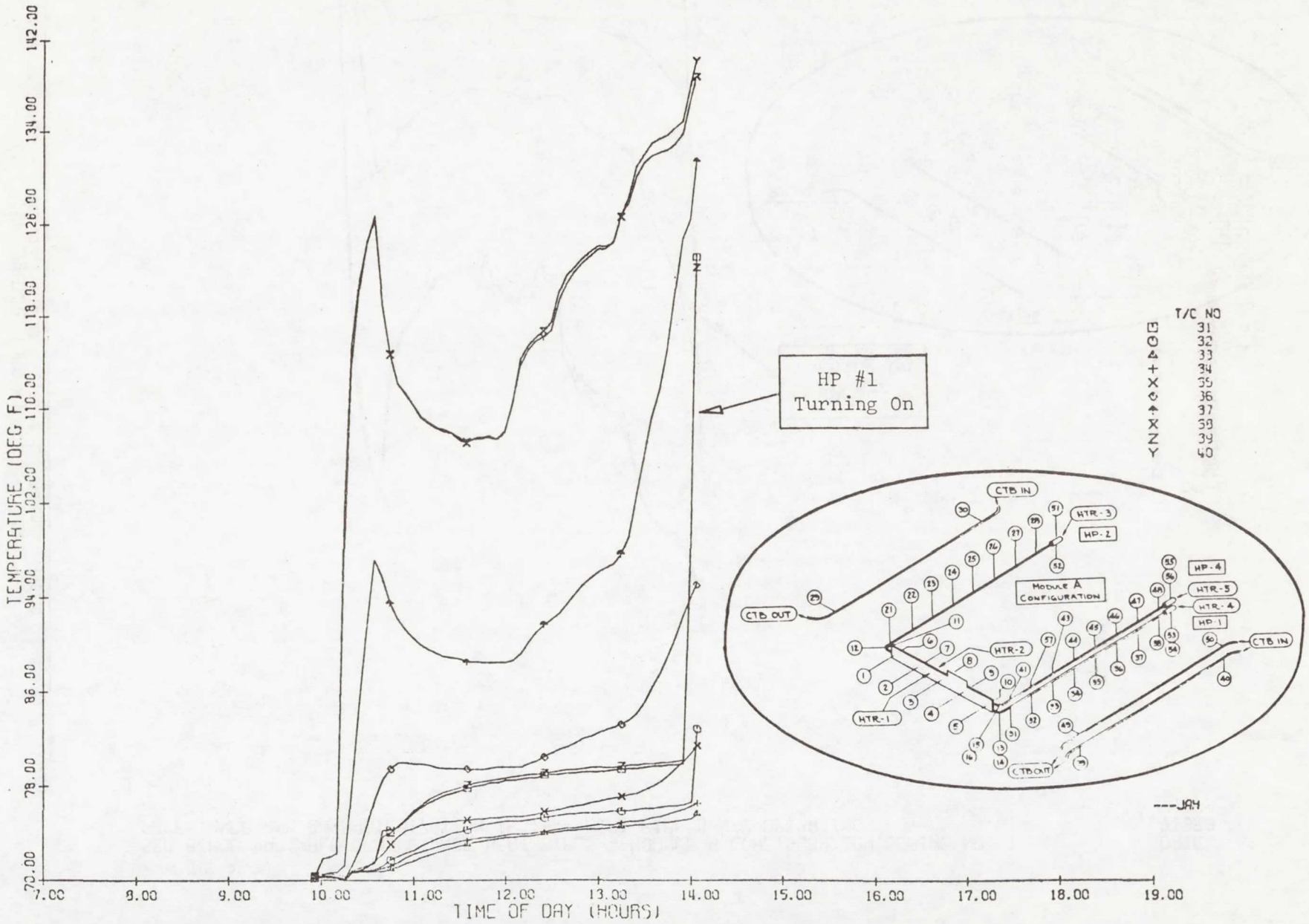


FIGURE A-7.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

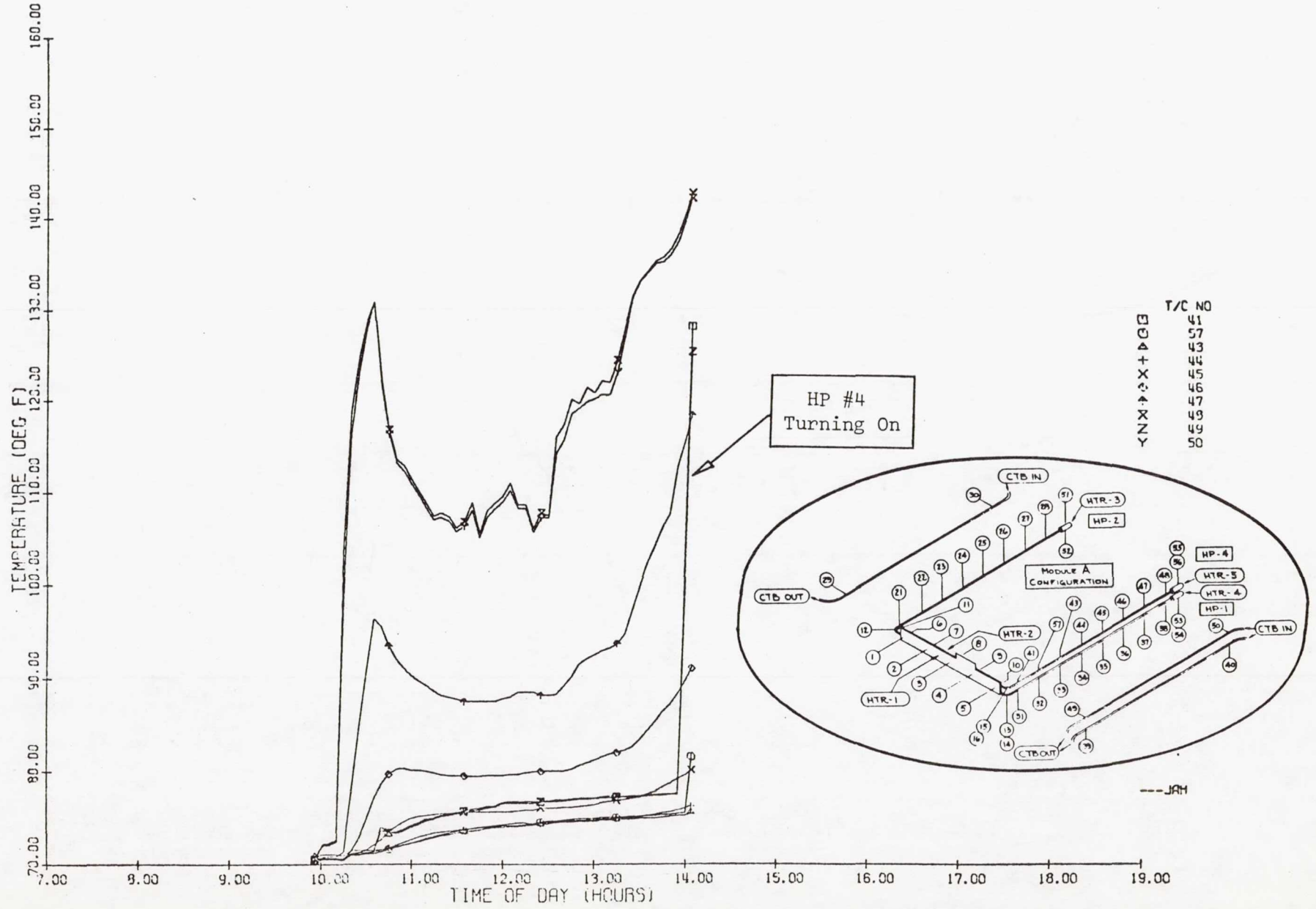


FIGURE A-7.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

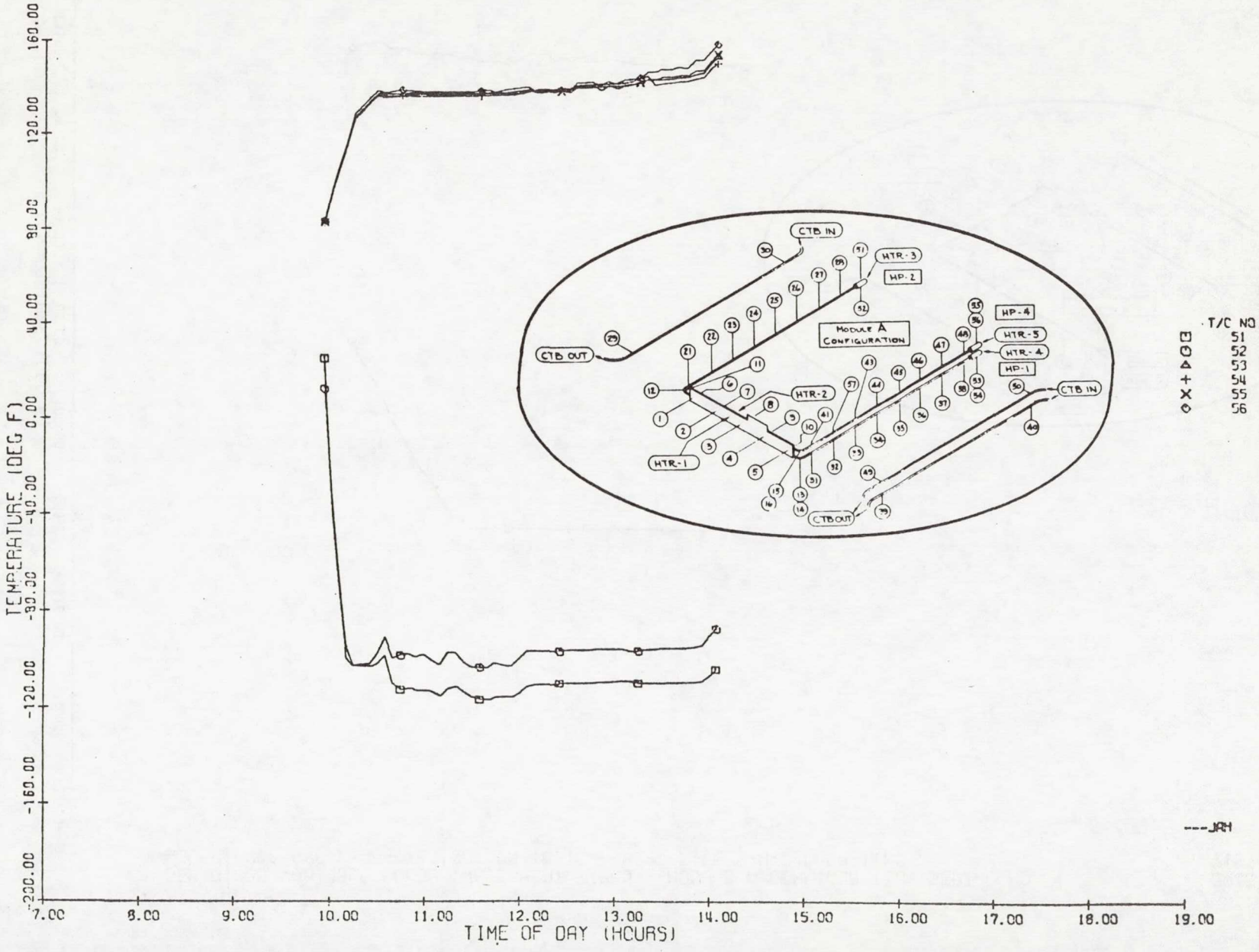


FIGURE A-7.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

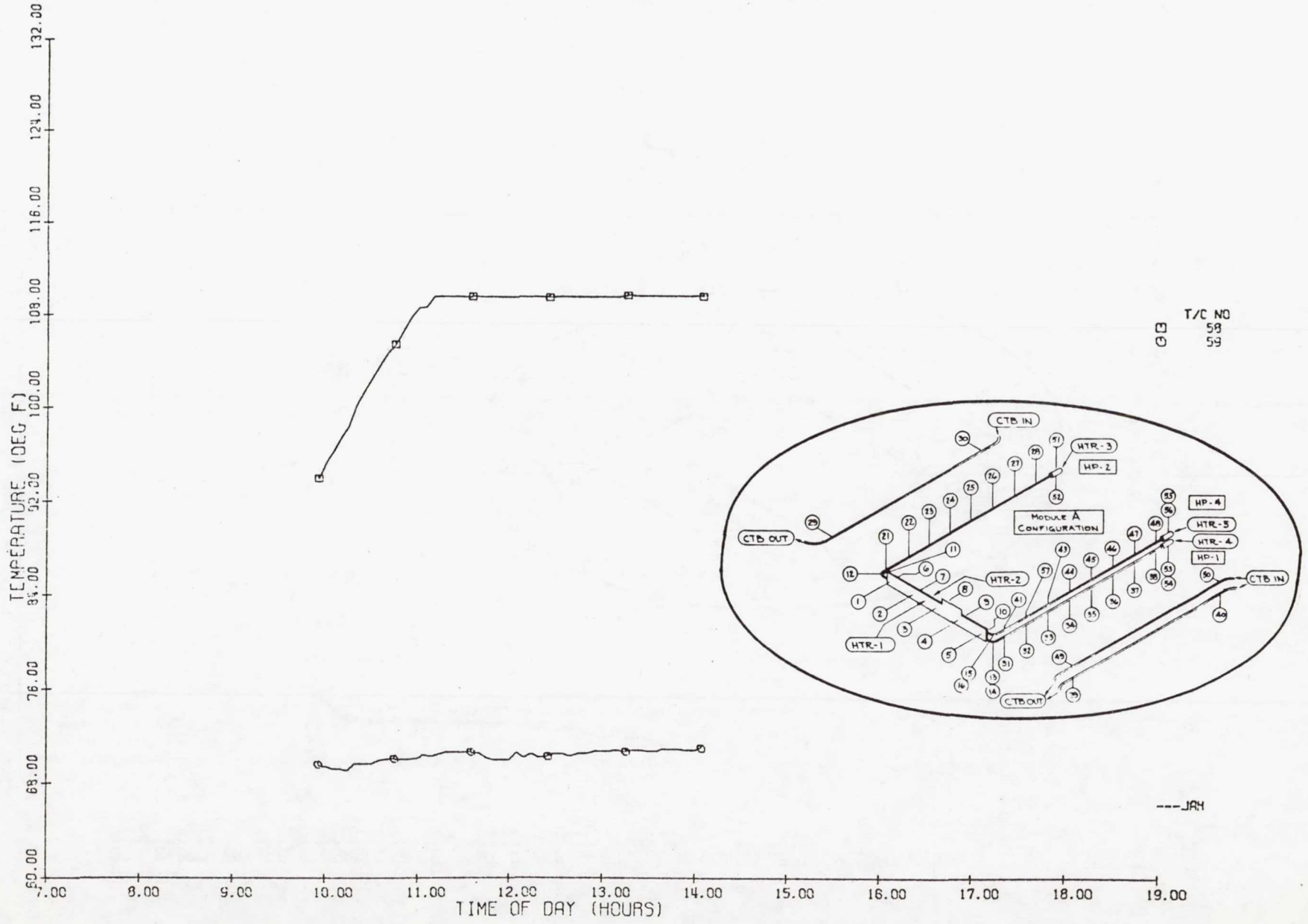


FIGURE A-7.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

DATE
71979

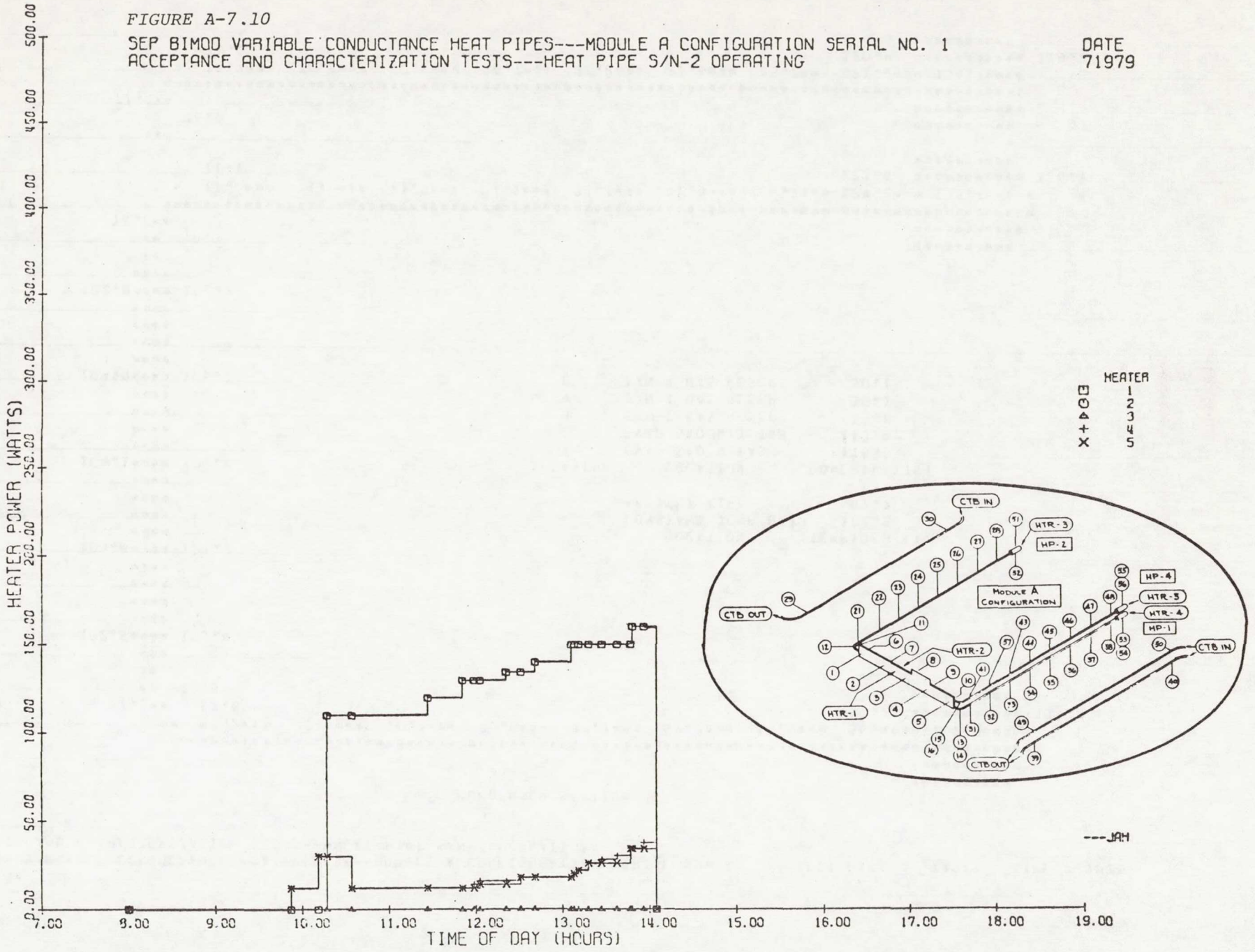


FIGURE A-7.11

SLP PIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 71979 TIME = 1025
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

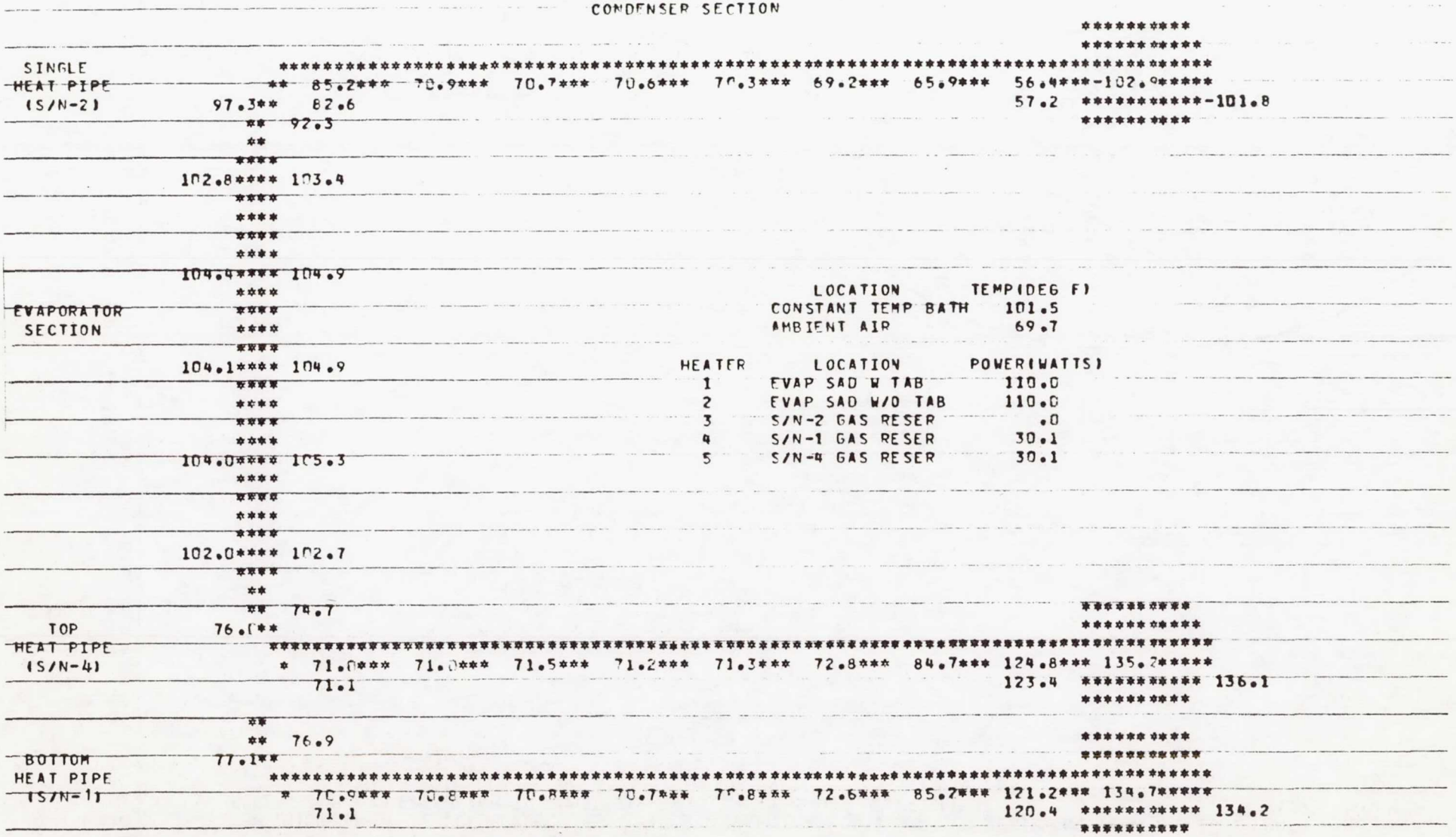


FIGURE A-7.12

SEP RIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 71979 TIME = 1125
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-2 OPERATING

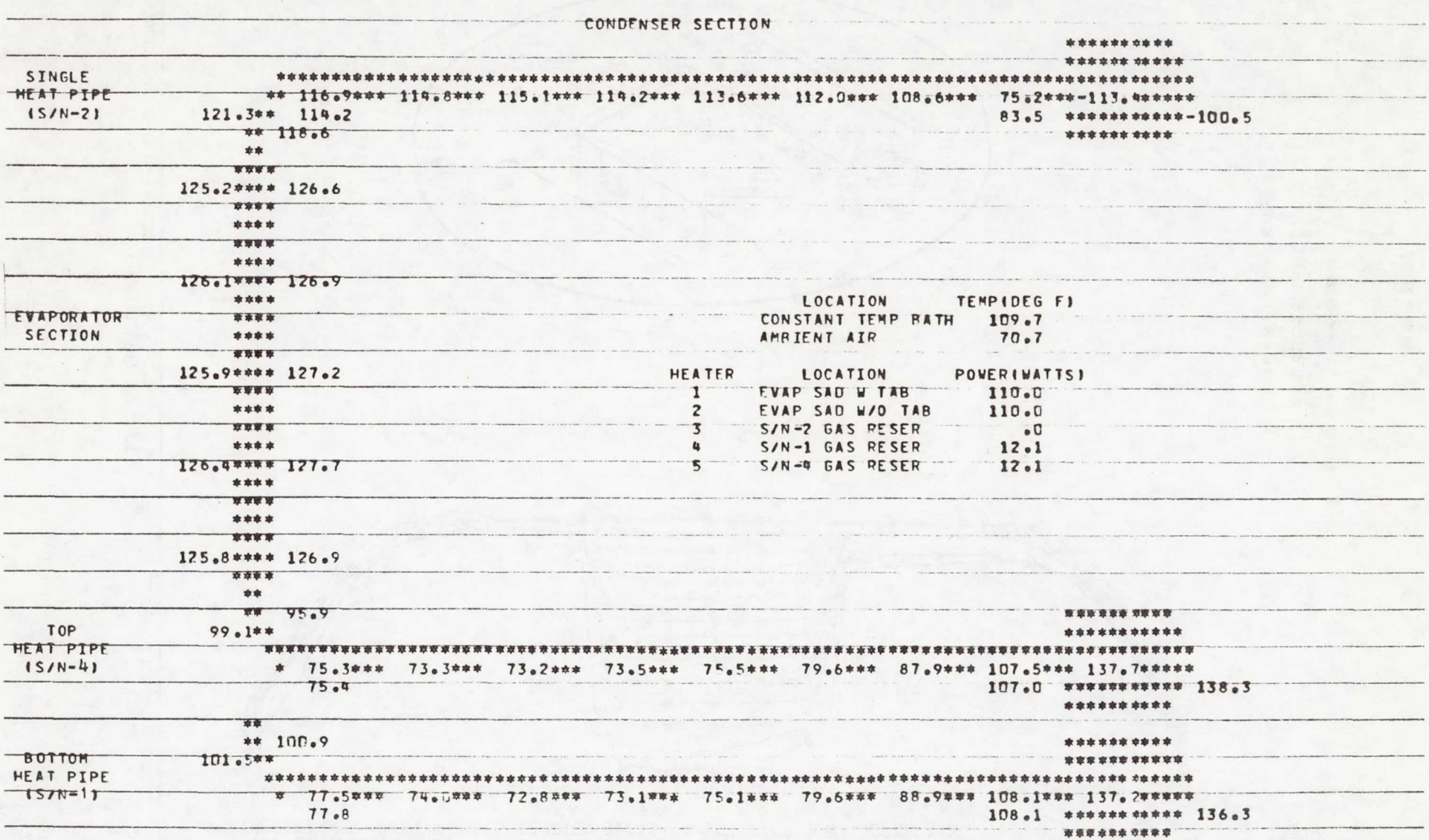


FIGURE A-8.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

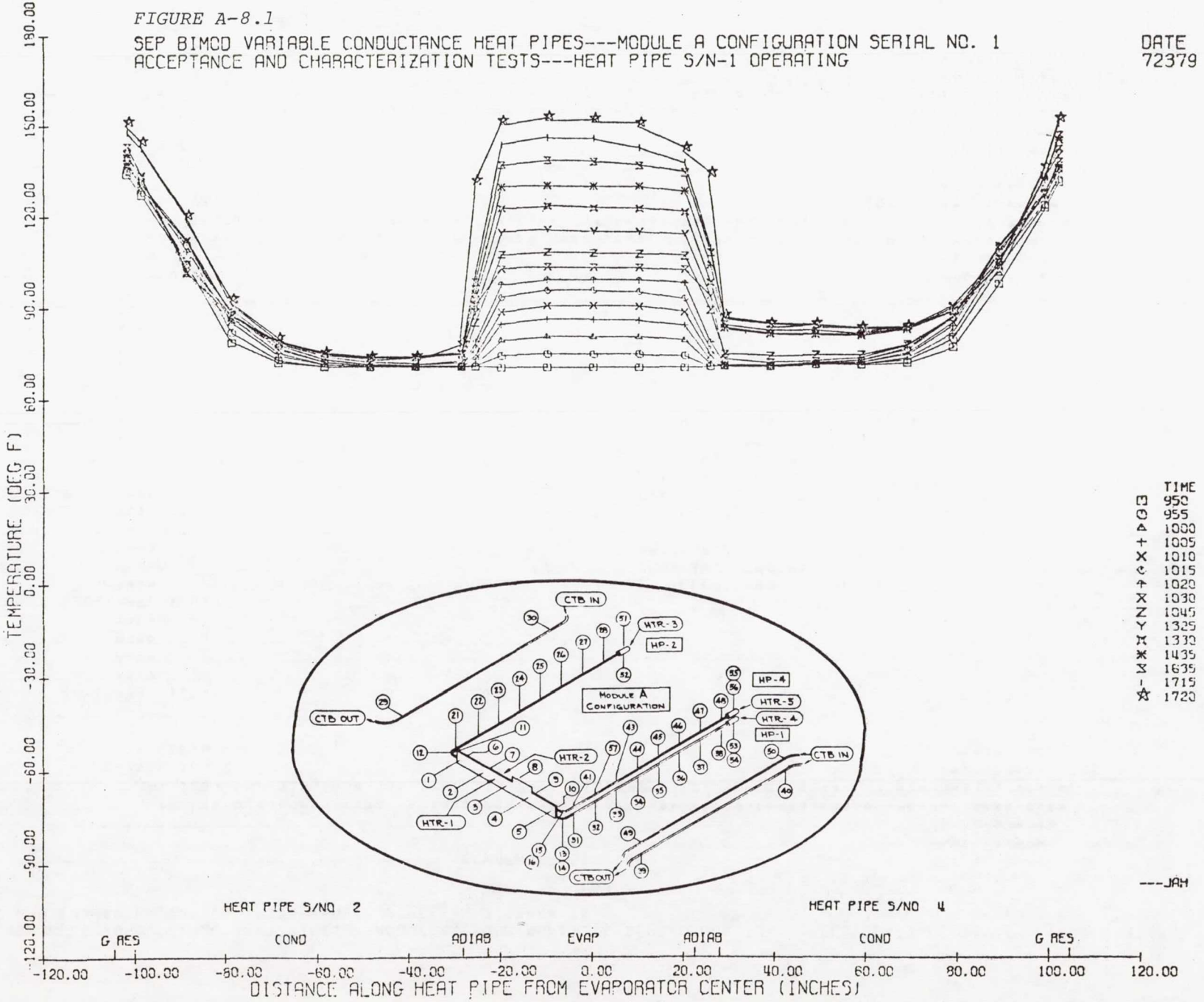


FIGURE A-8.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

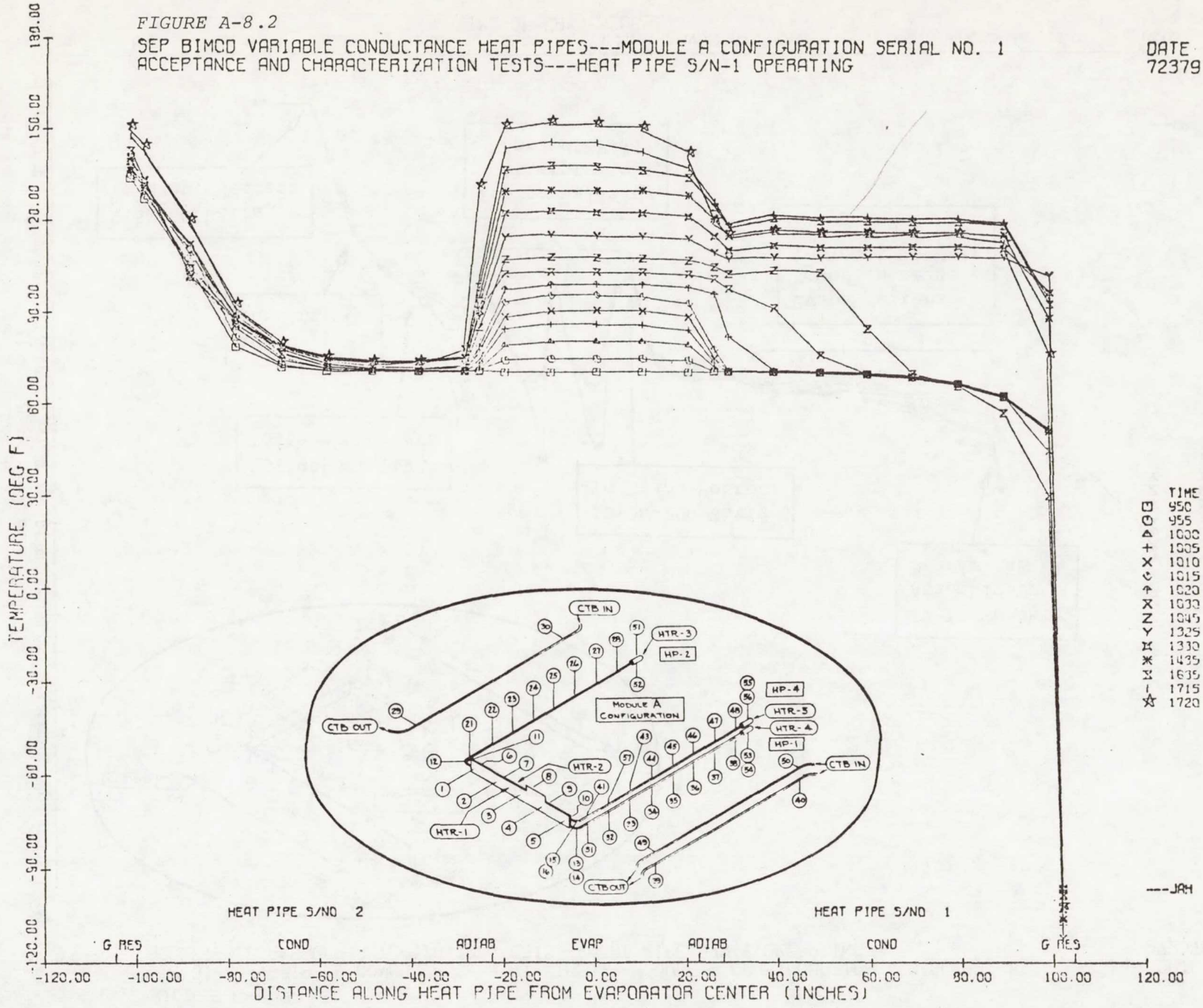


FIGURE A-8.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

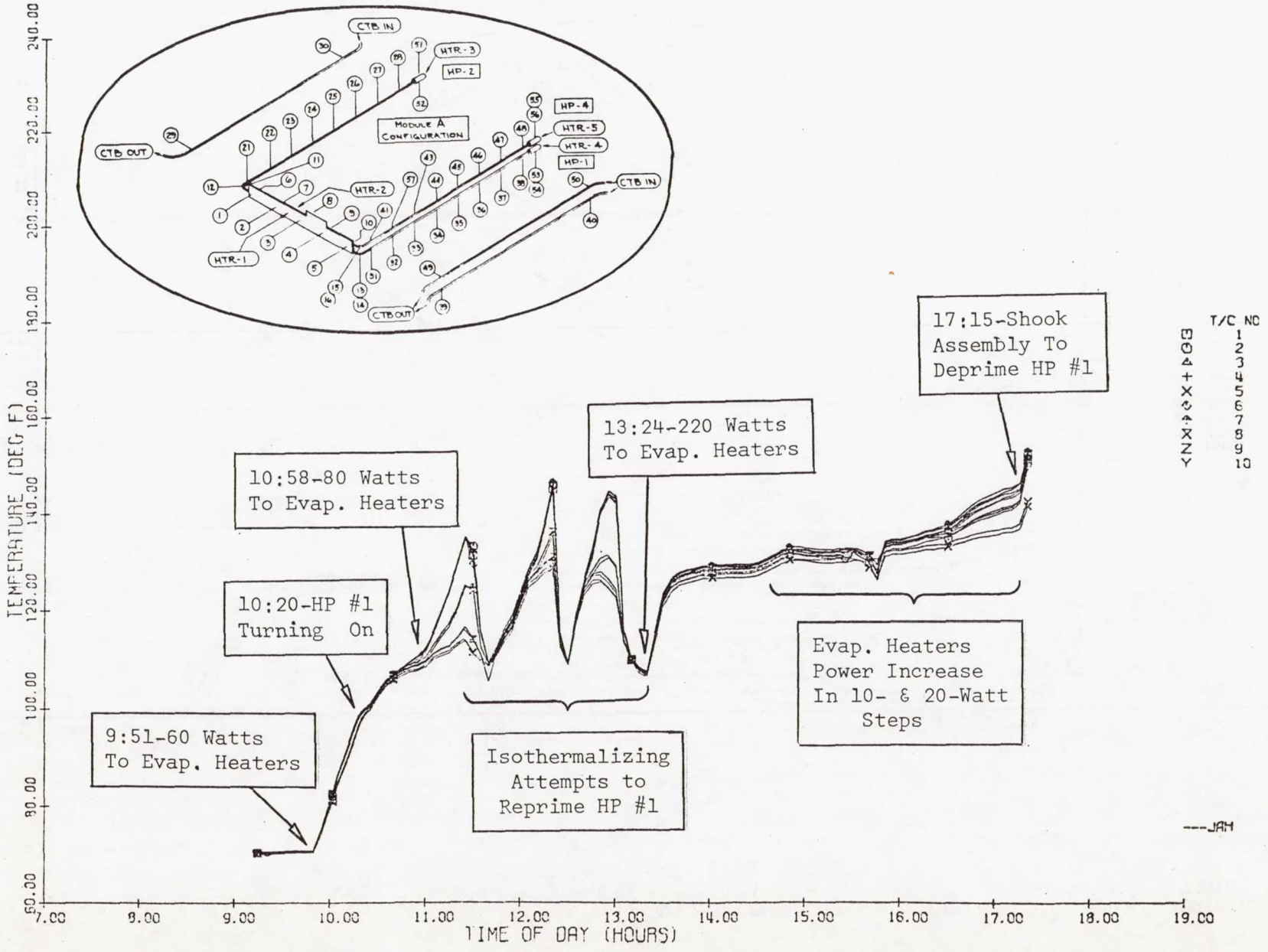


FIGURE A-8.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
7/23/79

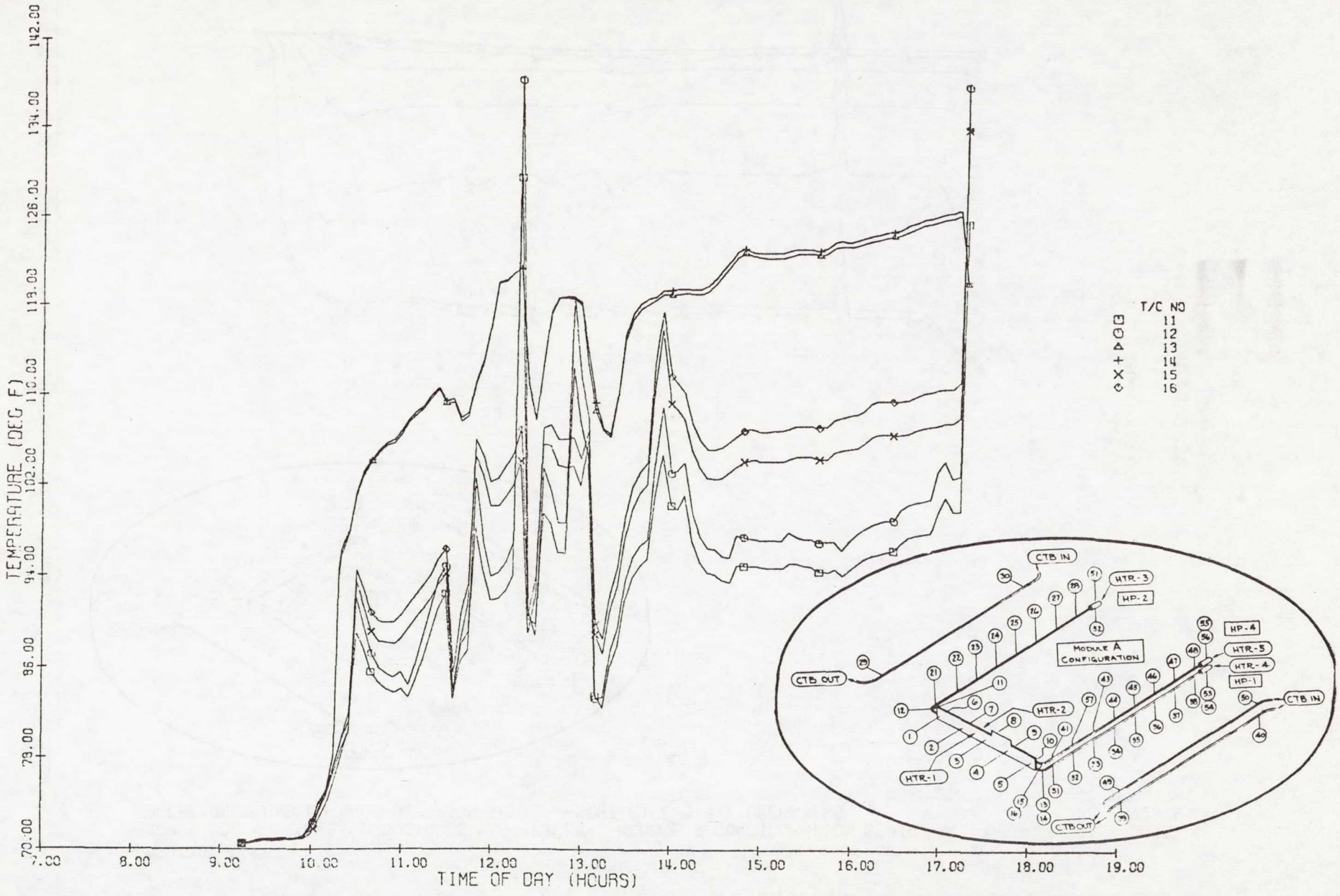


FIGURE A-8.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

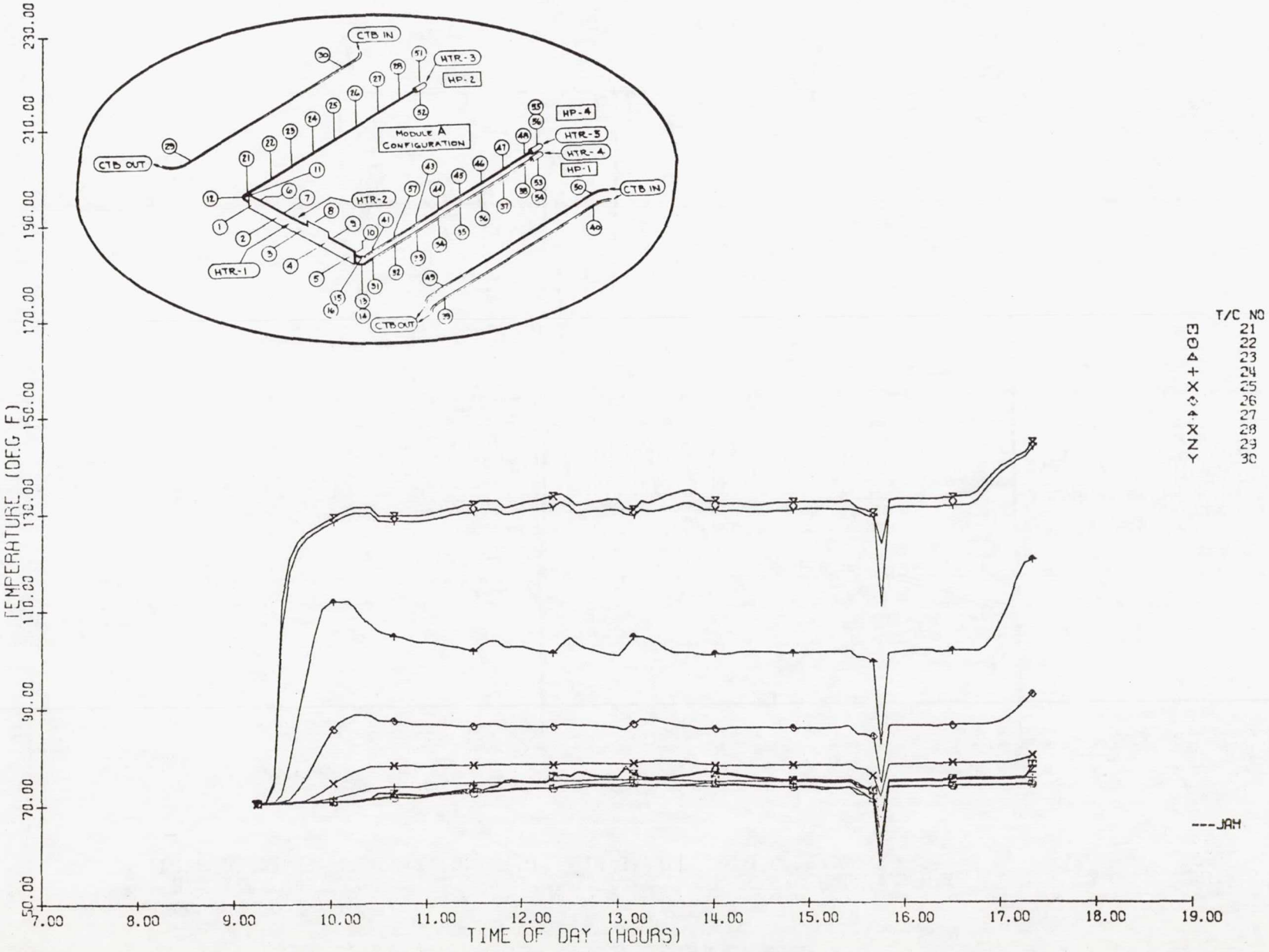


FIGURE A-8.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

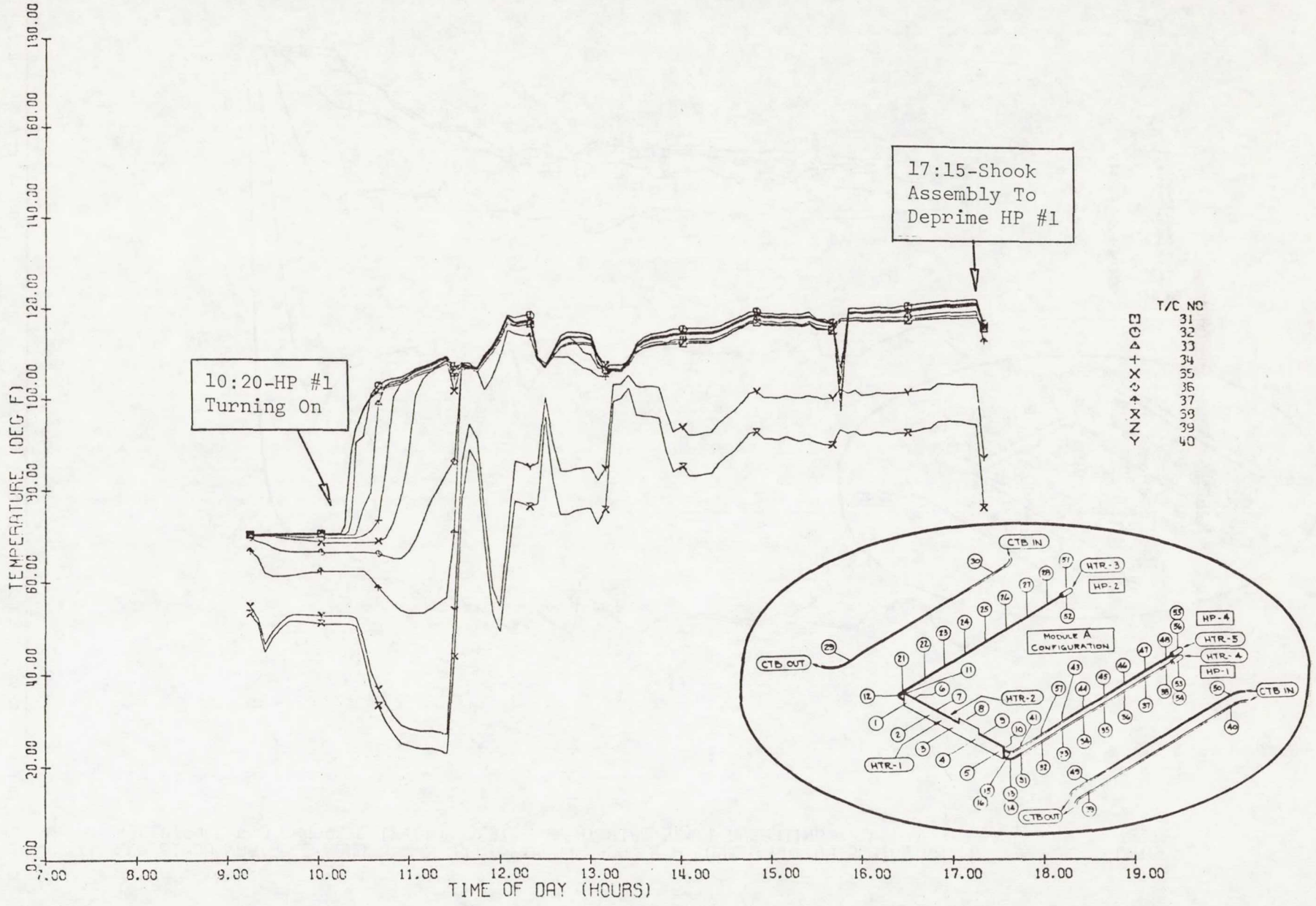


FIGURE A-8.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 DATE
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING 72379

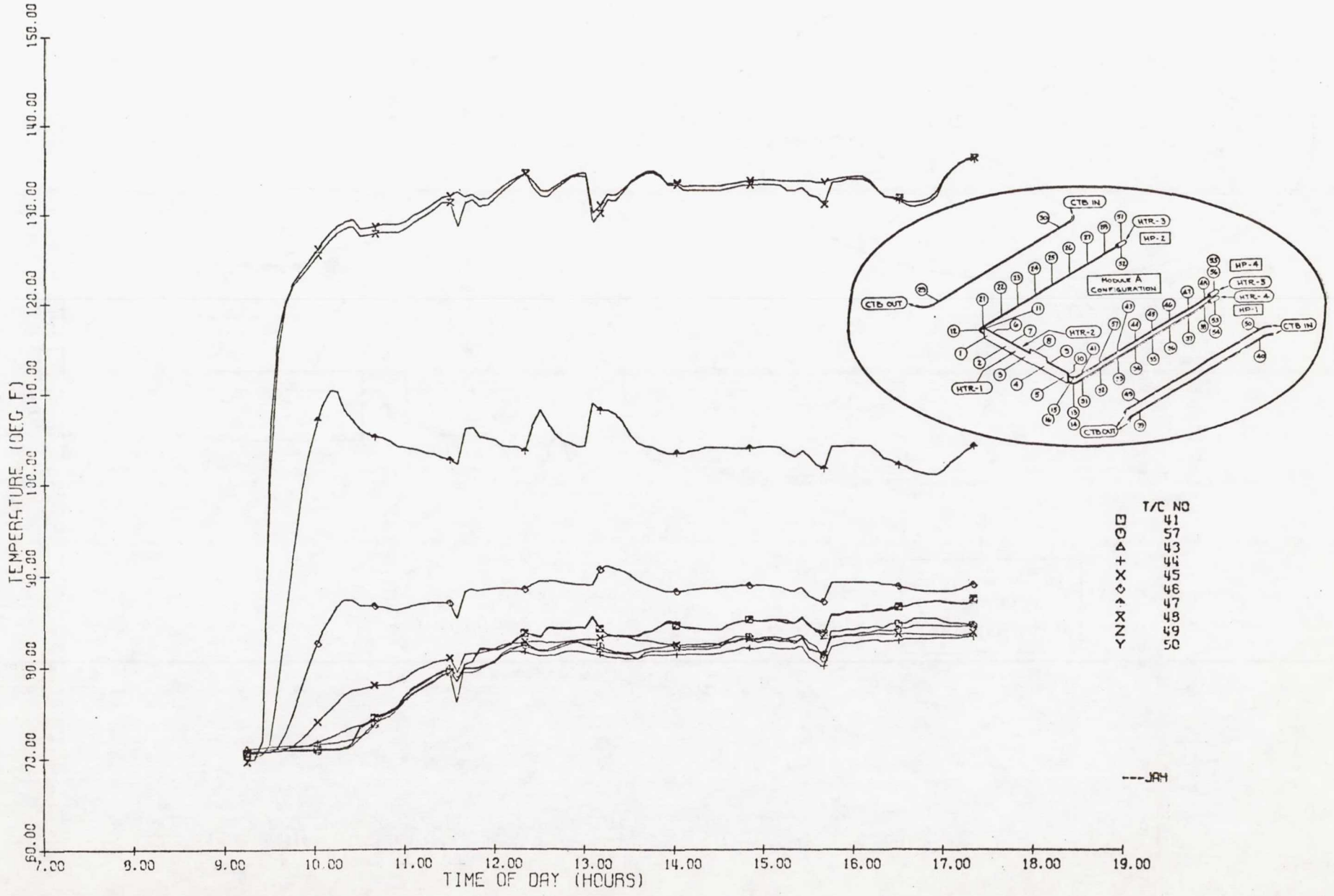


FIGURE A-8.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

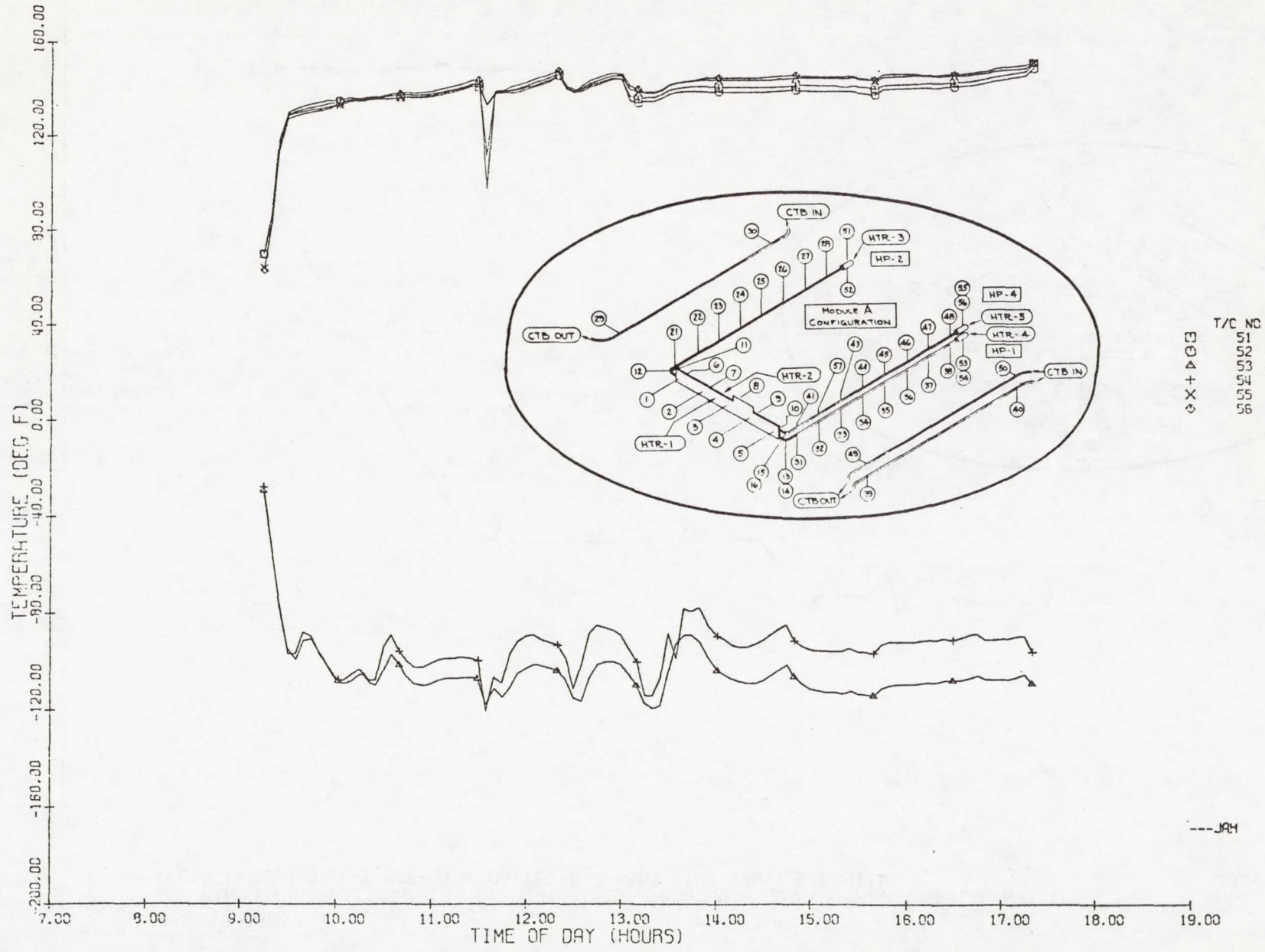


FIGURE A-8.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

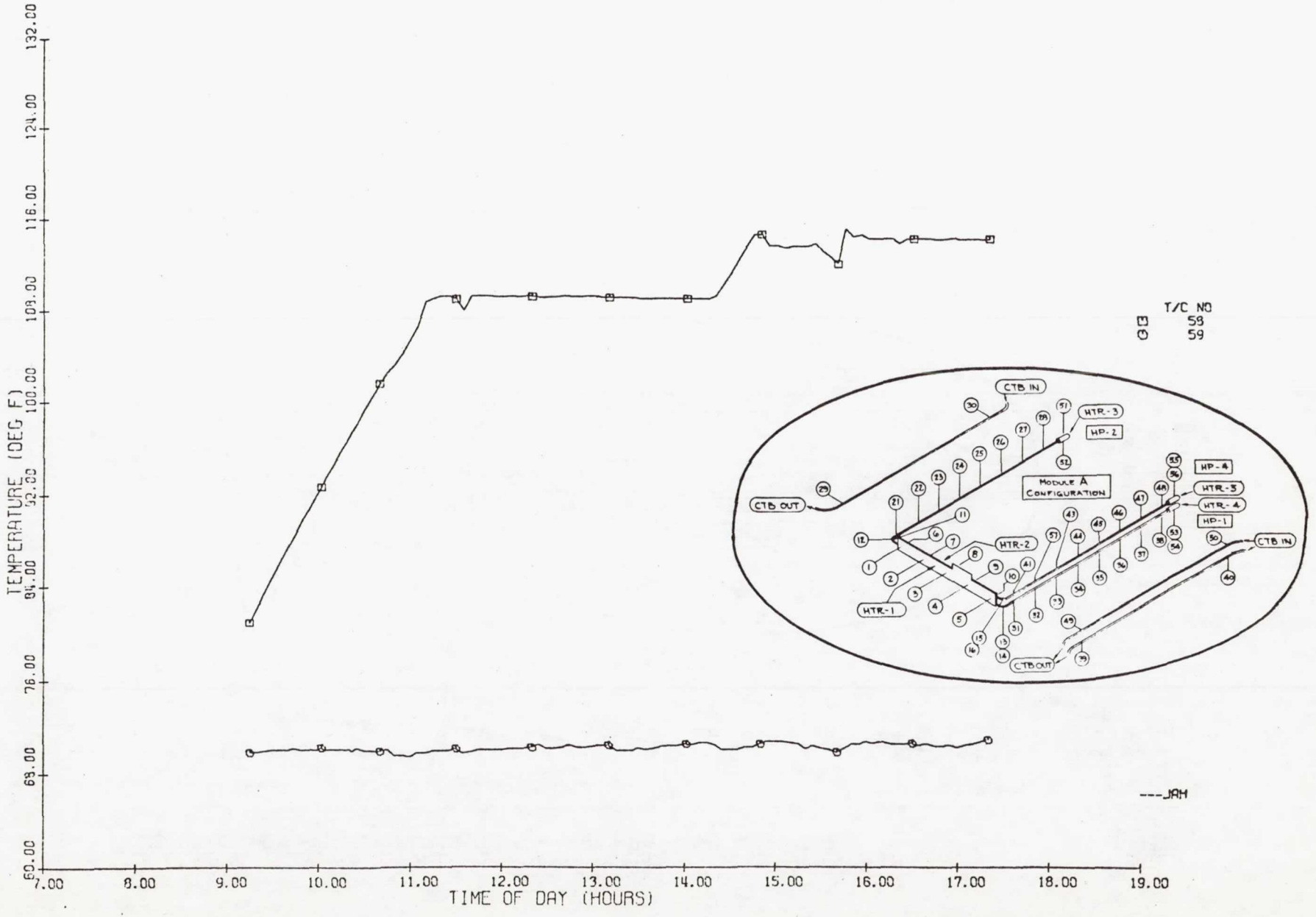


FIGURE A-8.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

DATE
72379

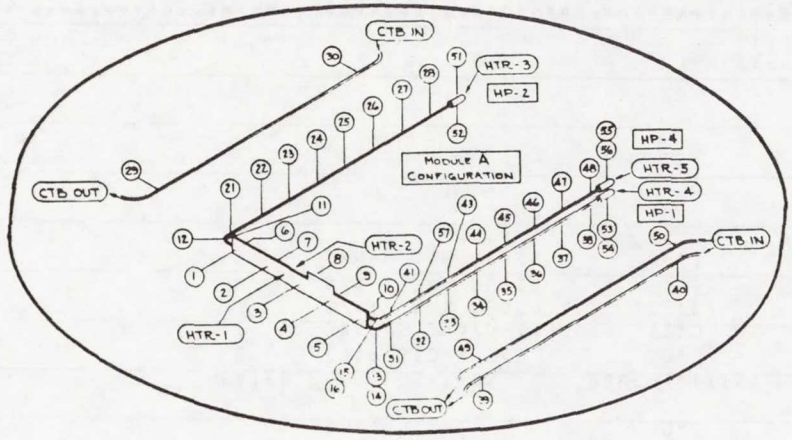


FIGURE A-8.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72379 TIME = 1025
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

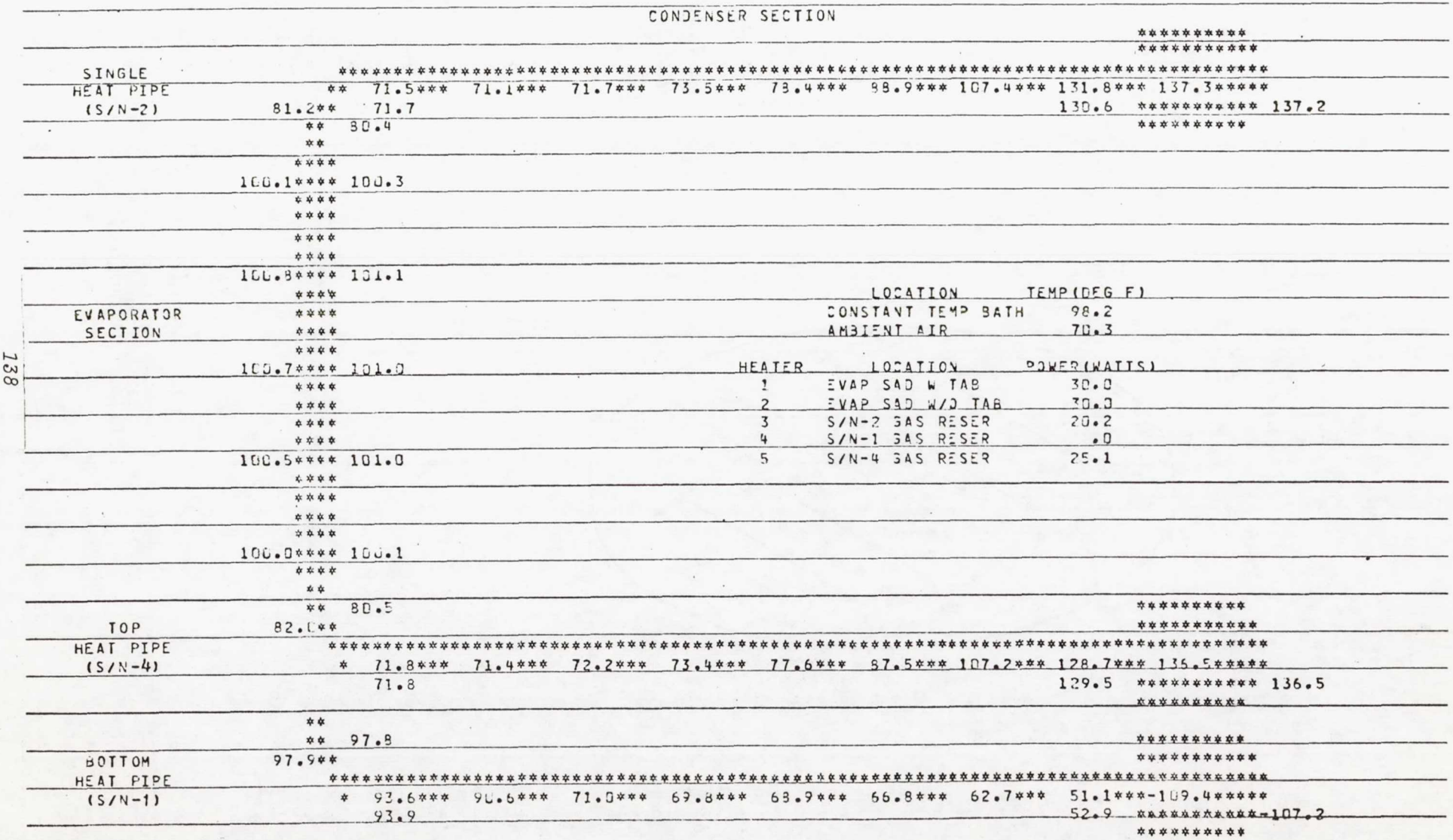


FIGURE A-8.12

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72379 TIME = 1515
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-1 OPERATING

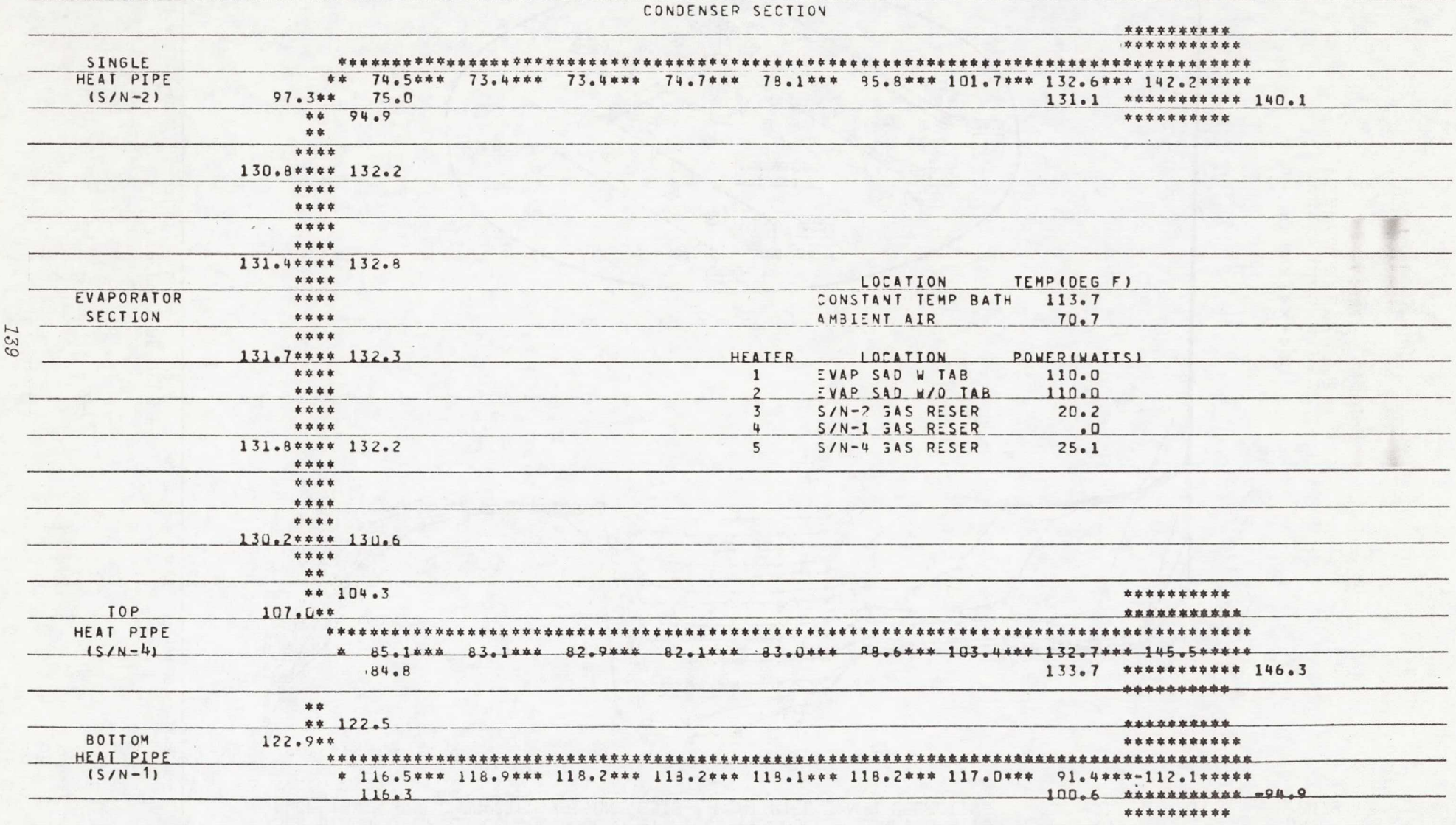


FIGURE A-9.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-4 OPERATING

DATE
72479

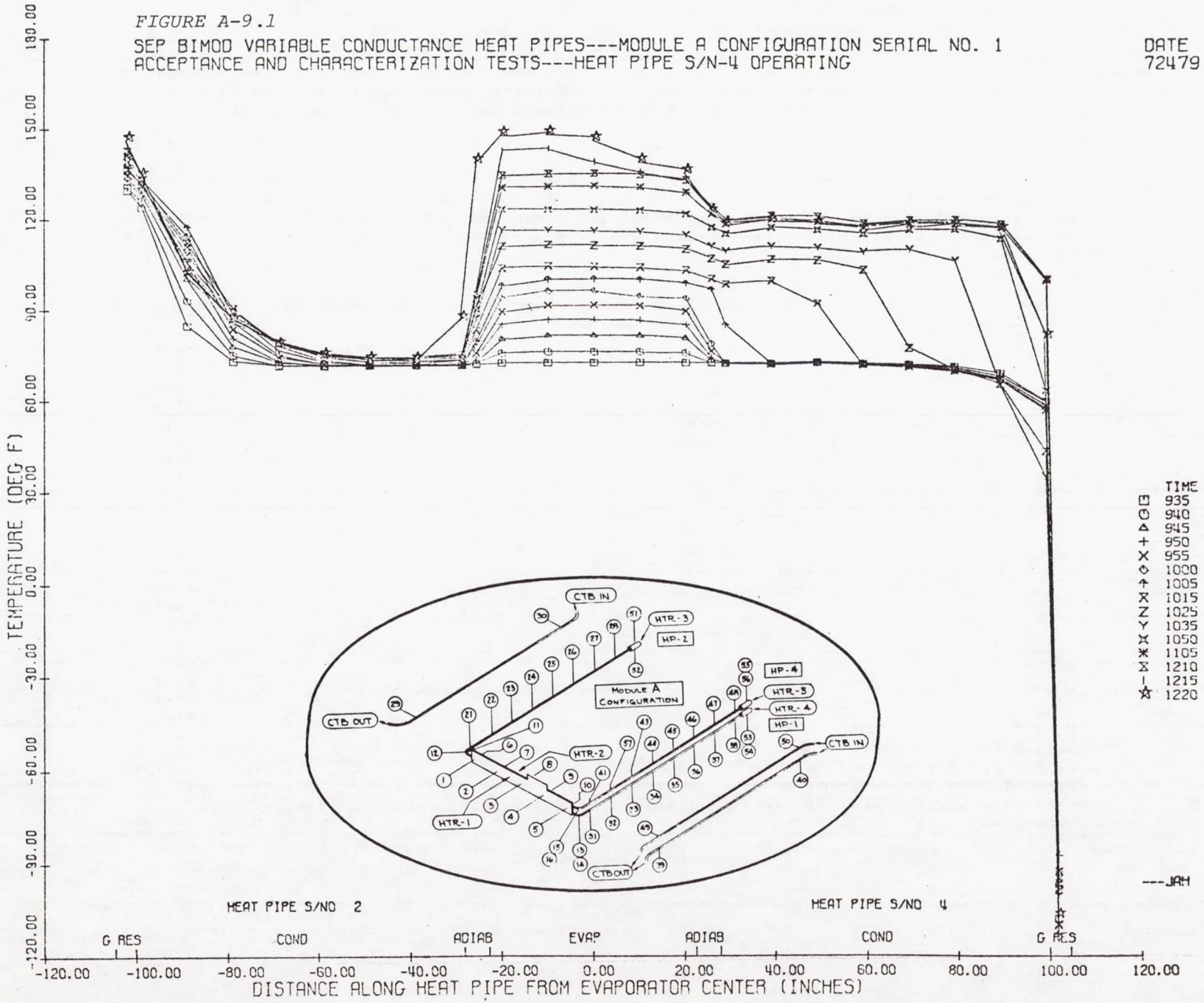


FIGURE A-9.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---HEAT PIPE S/N-4 OPERATING

DATE
72479

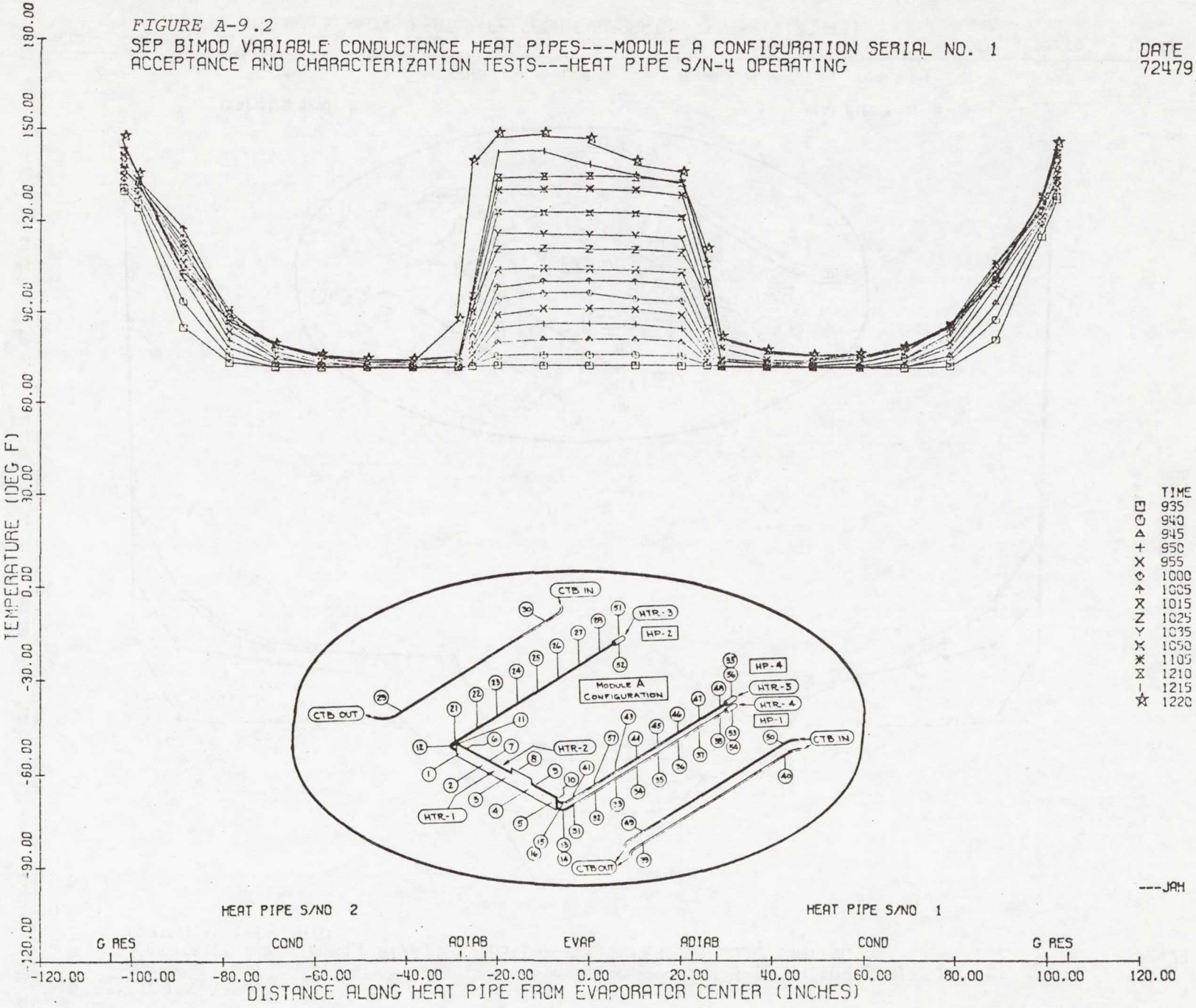


FIGURE A-9.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
72479

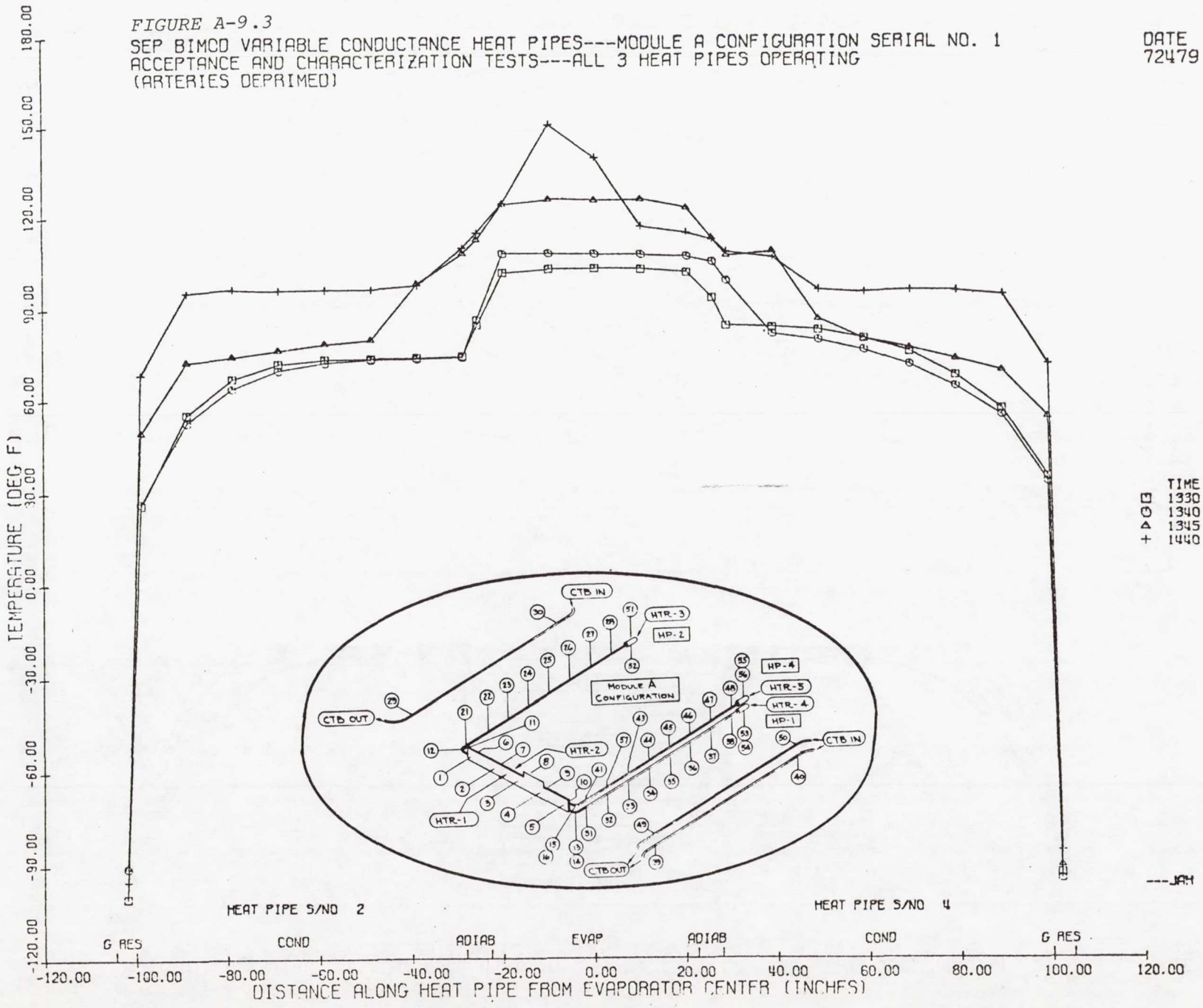


FIGURE A-9.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES DEPRIMED)

DATE
72479

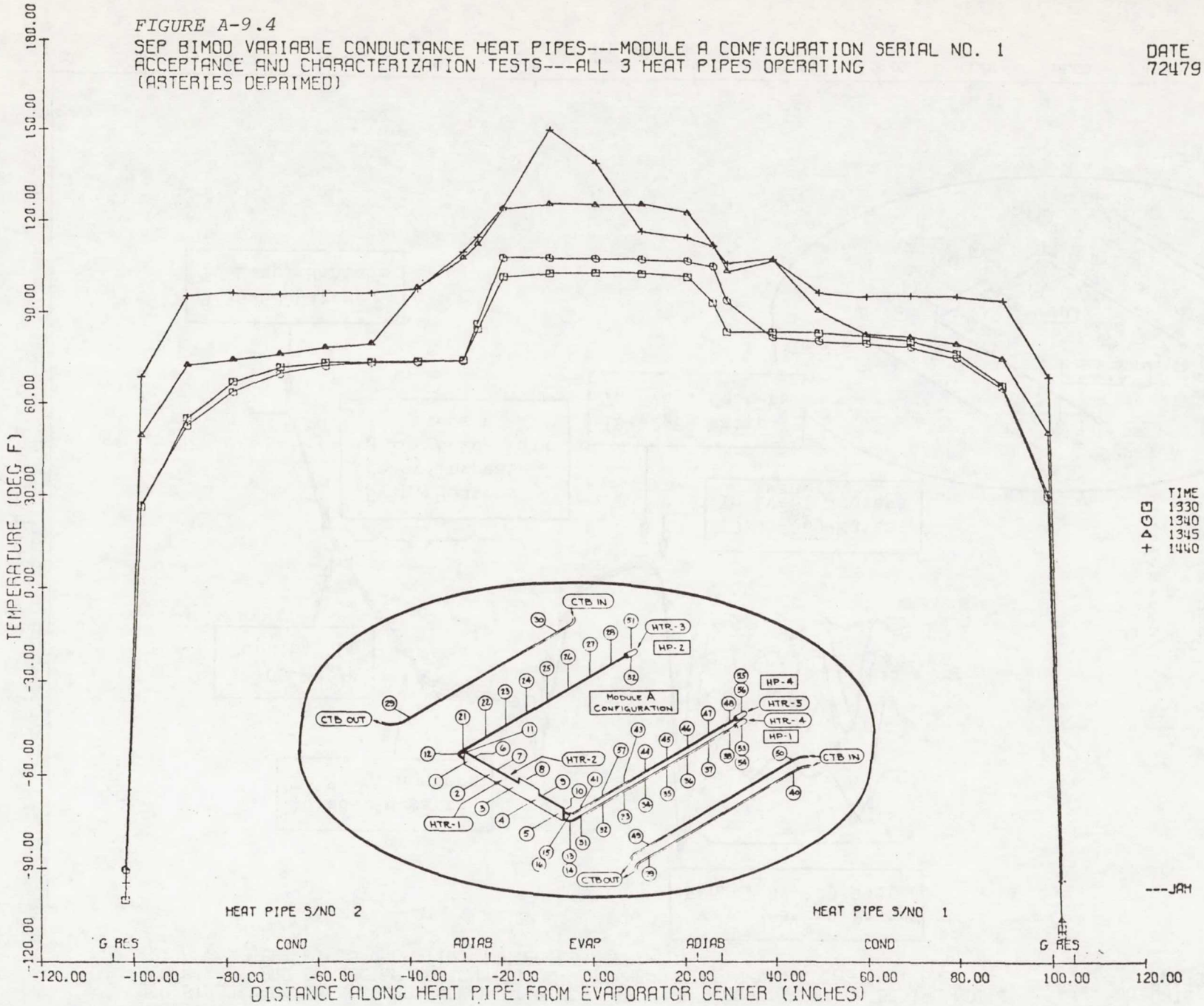


FIGURE A-9.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE
72479

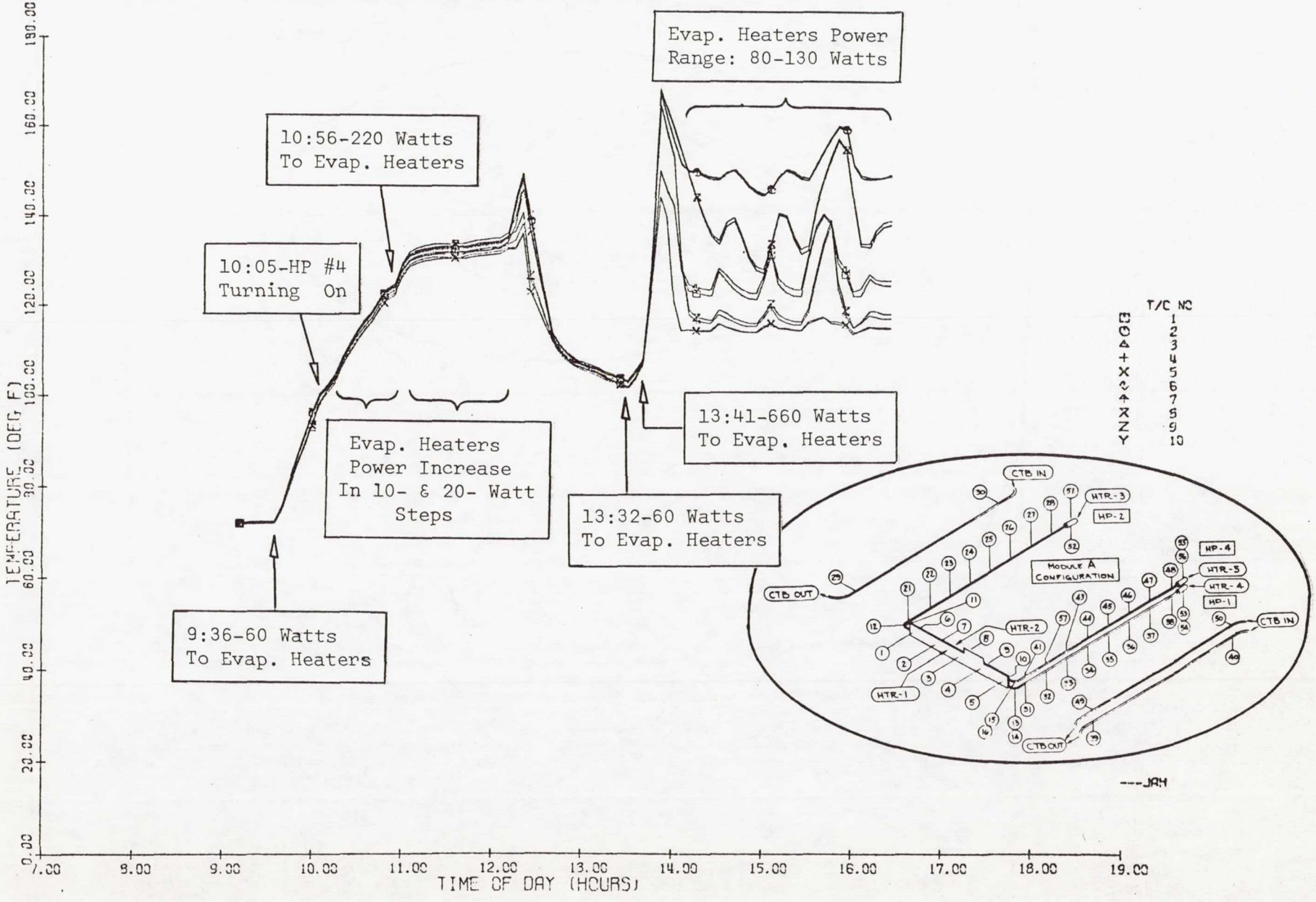


FIGURE A-9.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND (2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE 72479

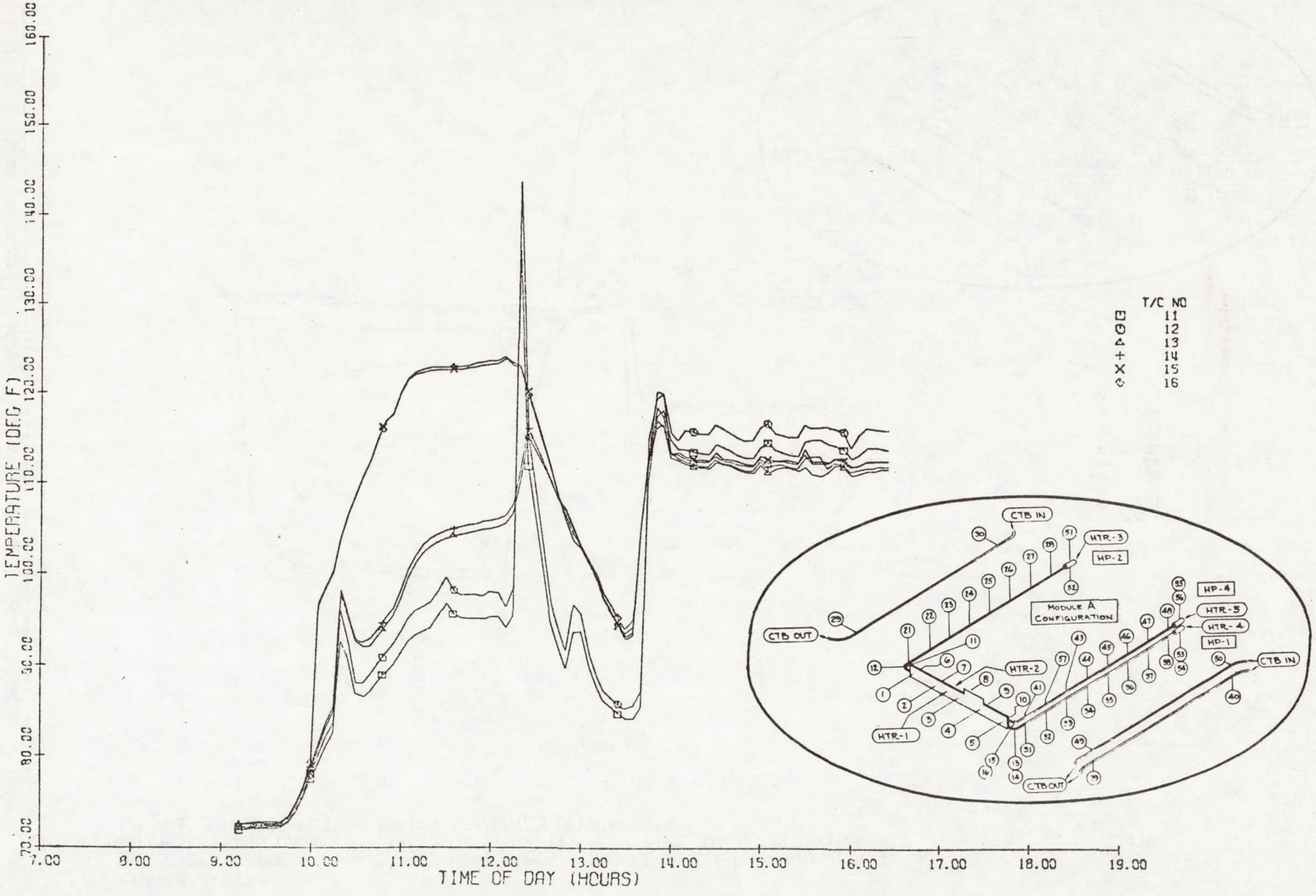


FIGURE A-9.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND (2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE 72479

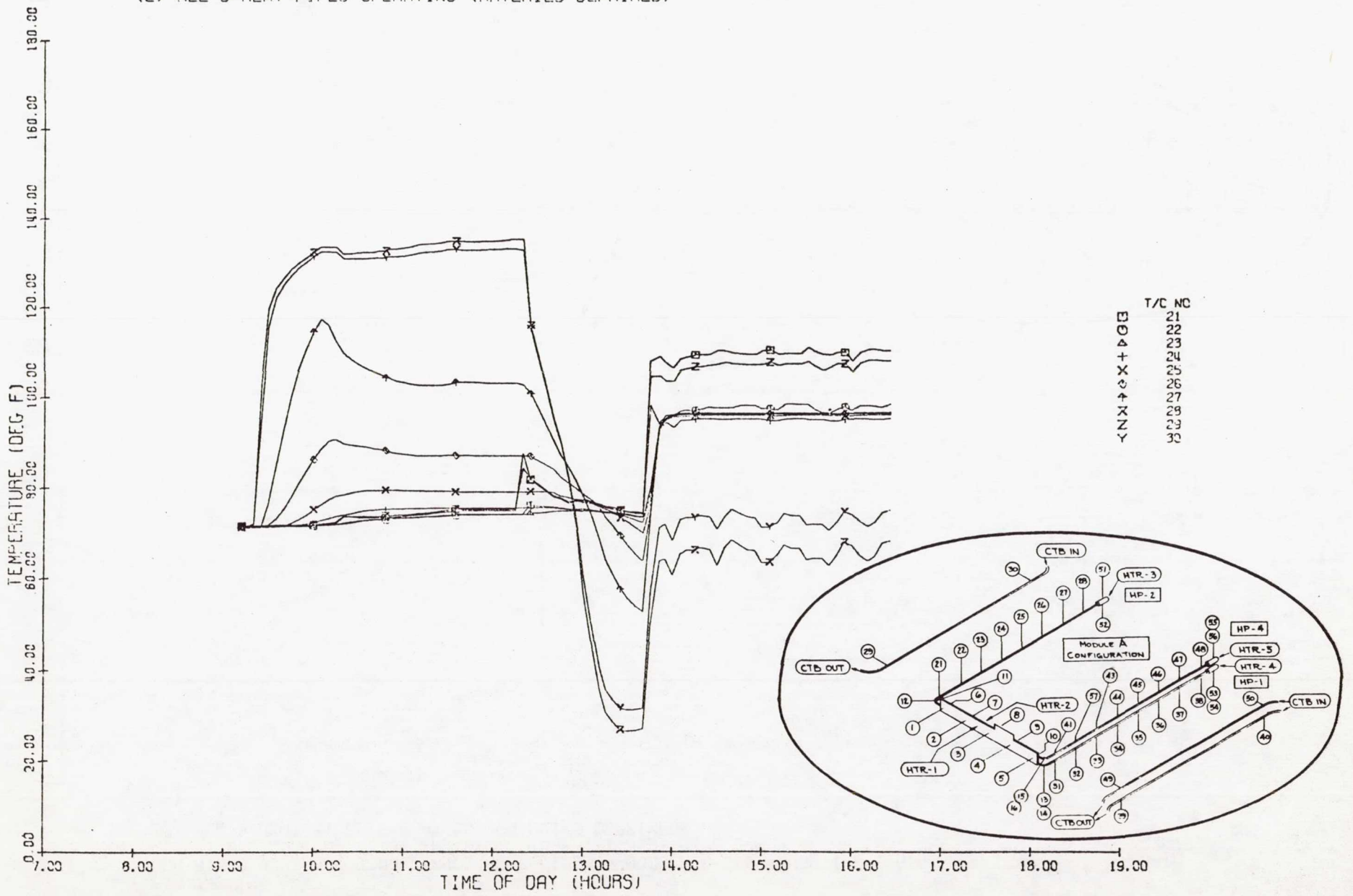


FIGURE A-9.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND (2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE 72479

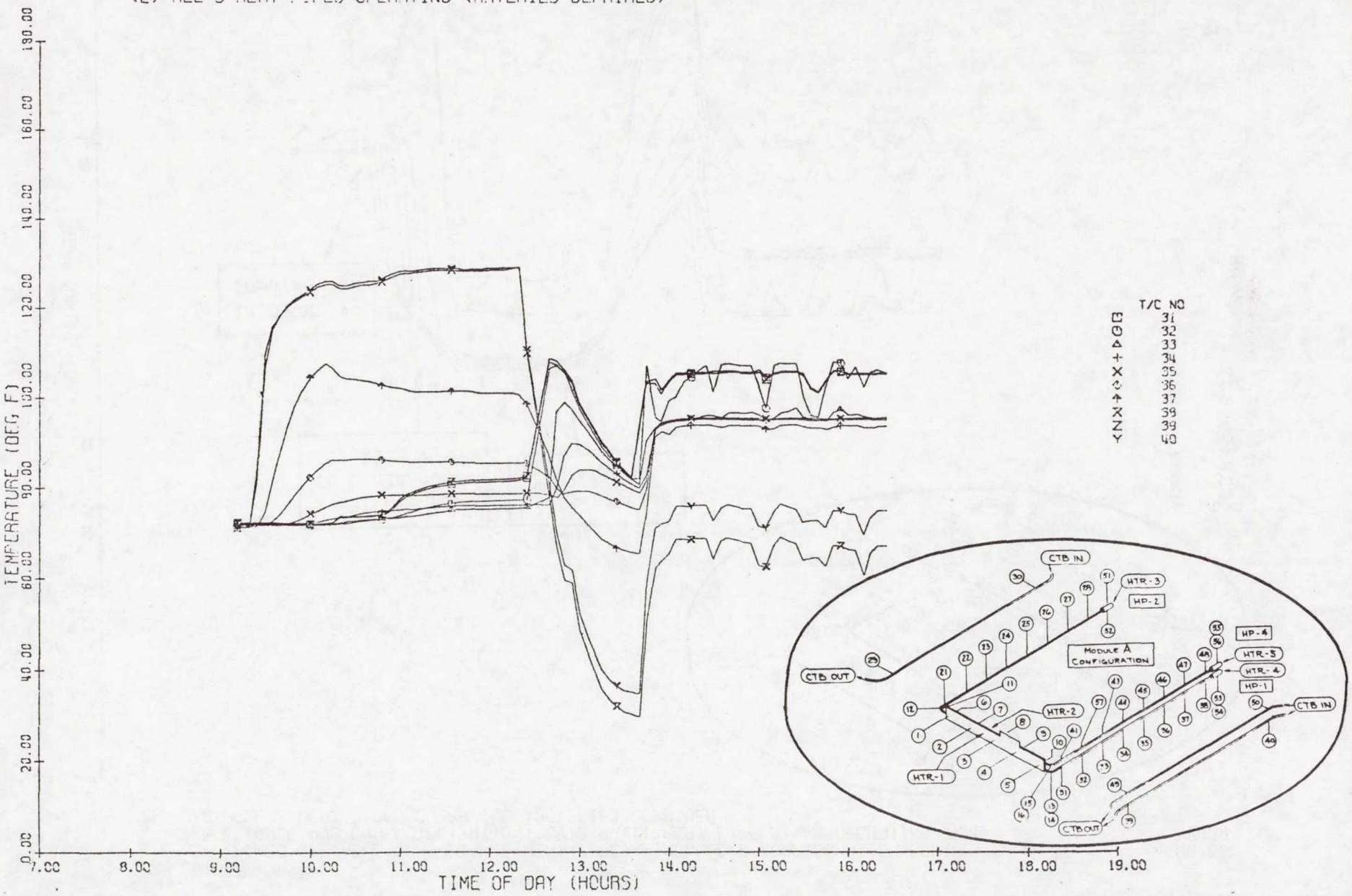


FIGURE A-9.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1. ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND (2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE 72479

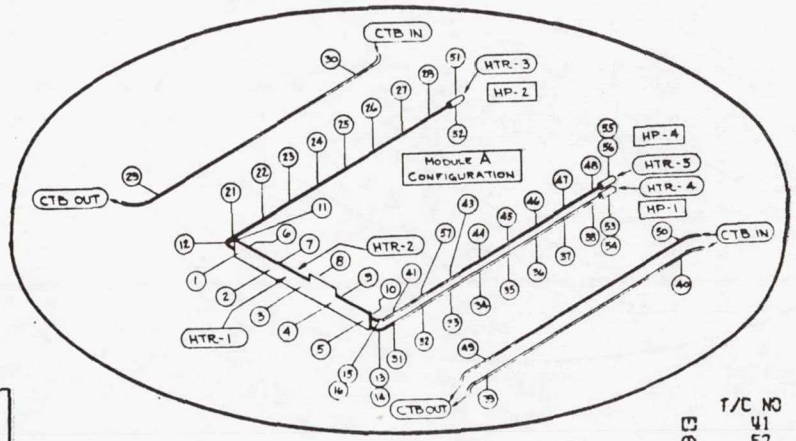


FIGURE A-9.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND (2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE 72479

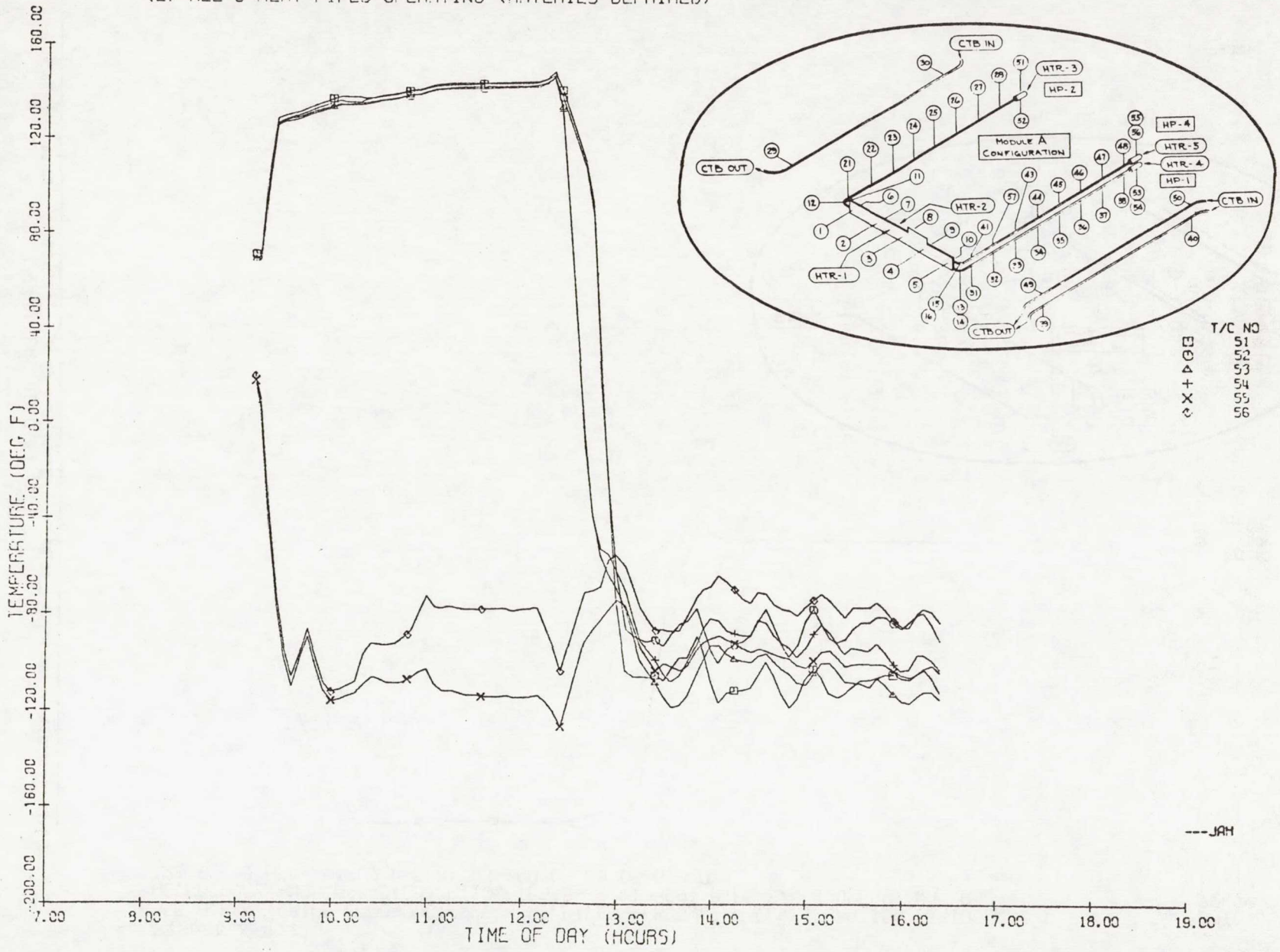


FIGURE A-9.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE
72479

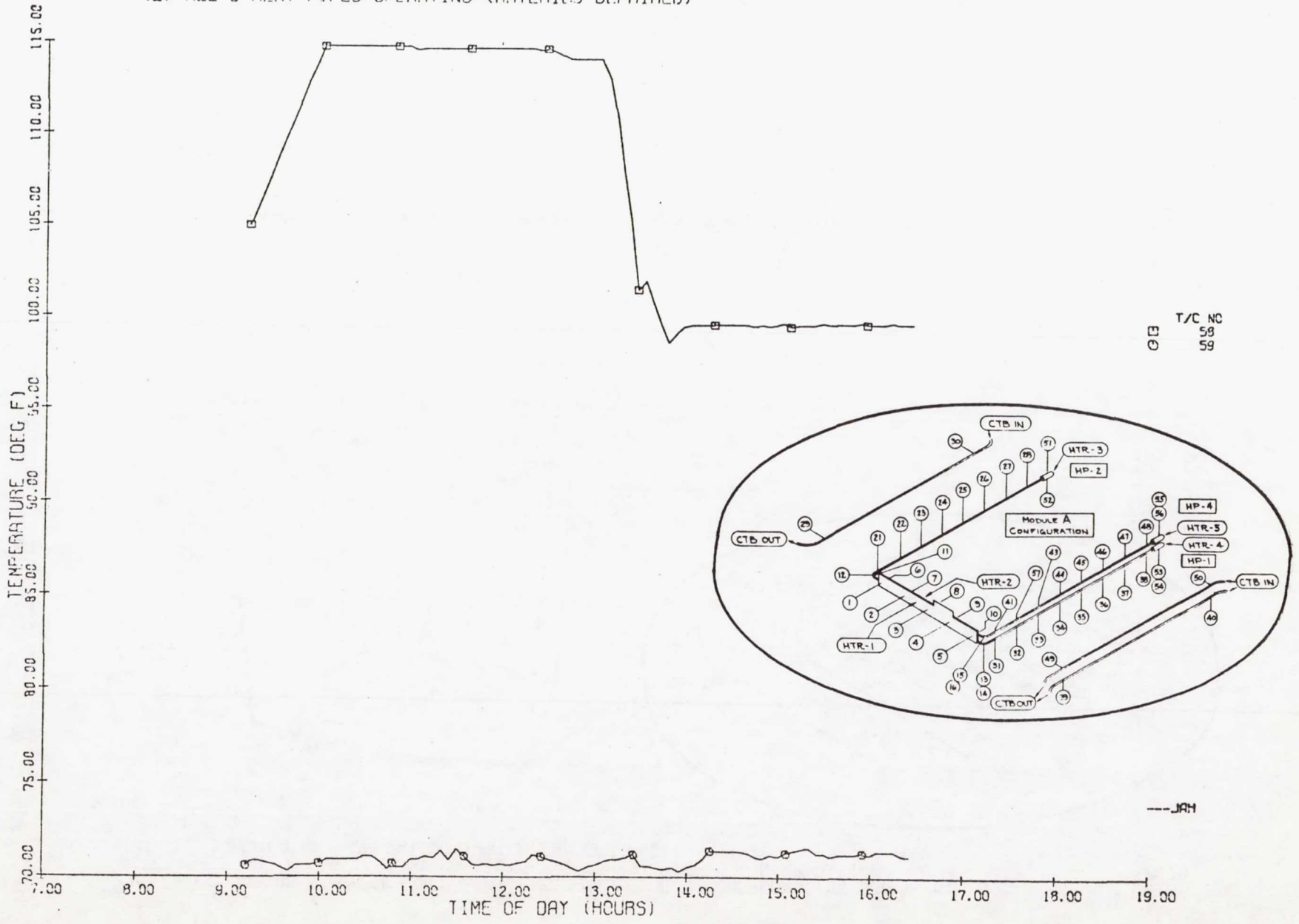


FIGURE A-9.12

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING. AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

DATE
72479

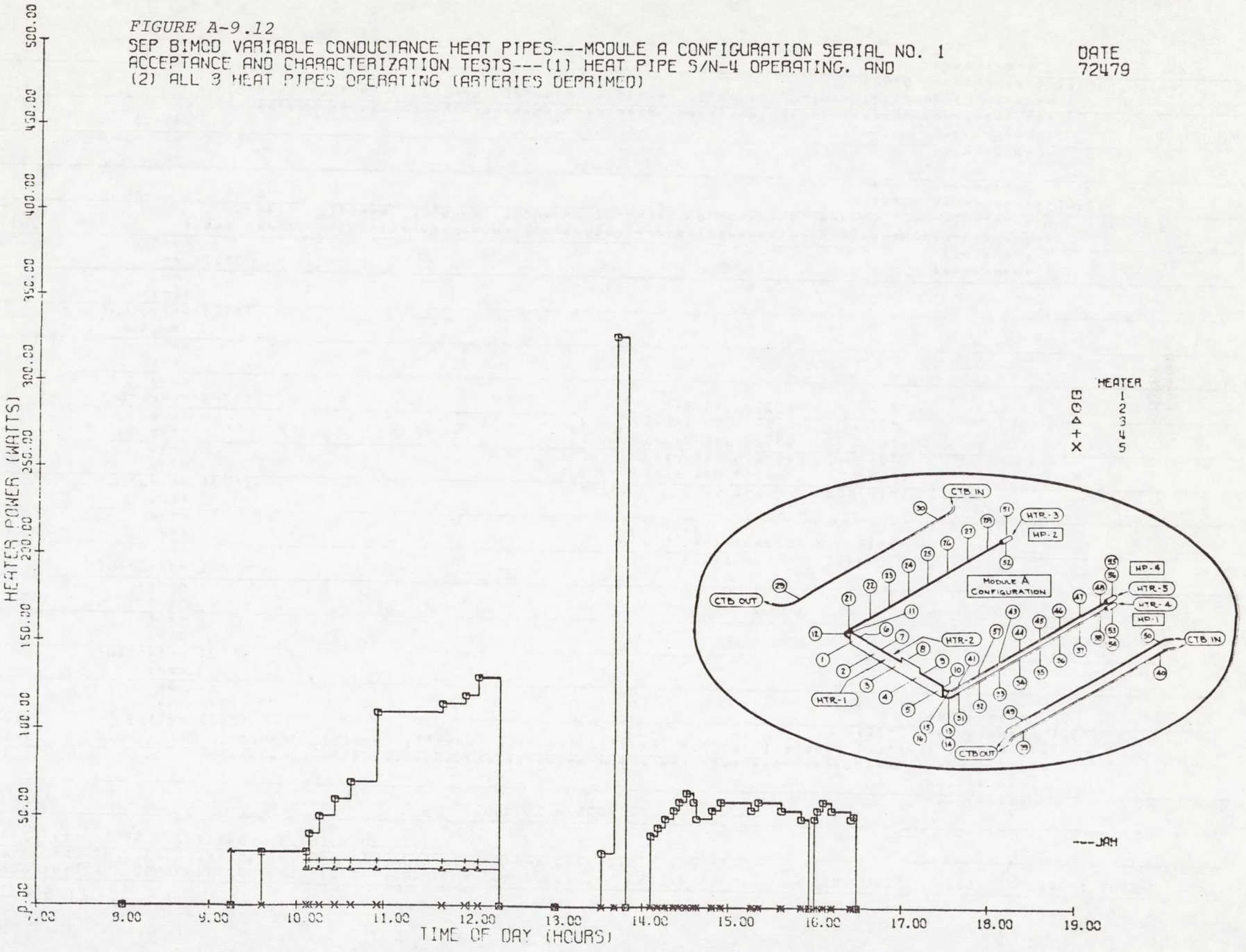
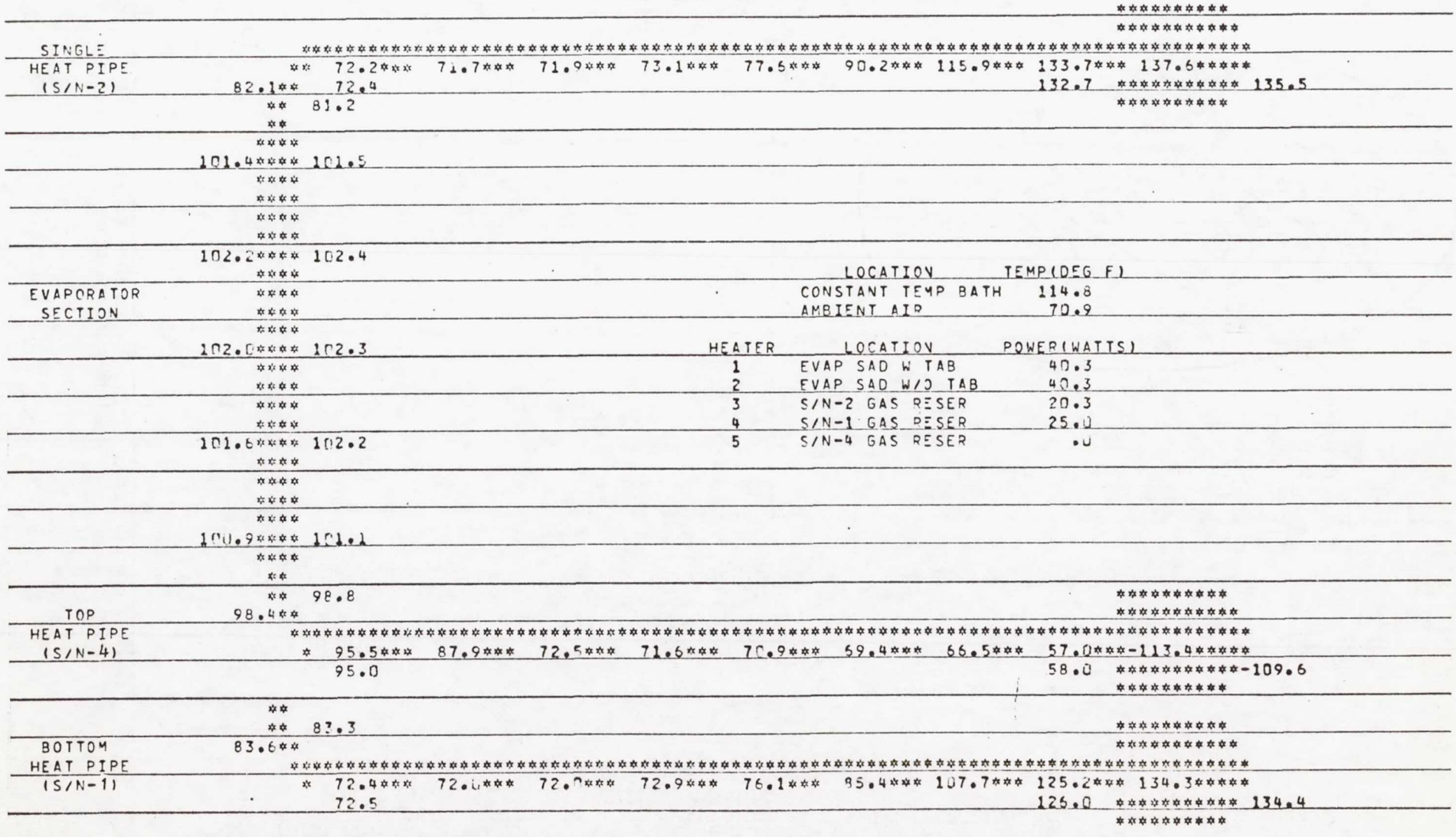


FIGURE A-9.13

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72479 TIME = 1010
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING, AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

CONDENSER SECTION



LOCATION	TEMP(DEG F)
CONSTANT TEMP BATH	114.8
AMBIENT AIR	70.9

HEATER	LOCATION	POWER(WATTS)
1	EVAP SAD W TAB	40.3
2	EVAP SAD W/O TAB	40.3
3	S/N-2 GAS RESER	20.3
4	S/N-1 GAS RESER	25.0
5	S/N-4 GAS RESER	.0

FIGURE A-9.14

SEP PIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72479 TIME = 1135
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING, AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

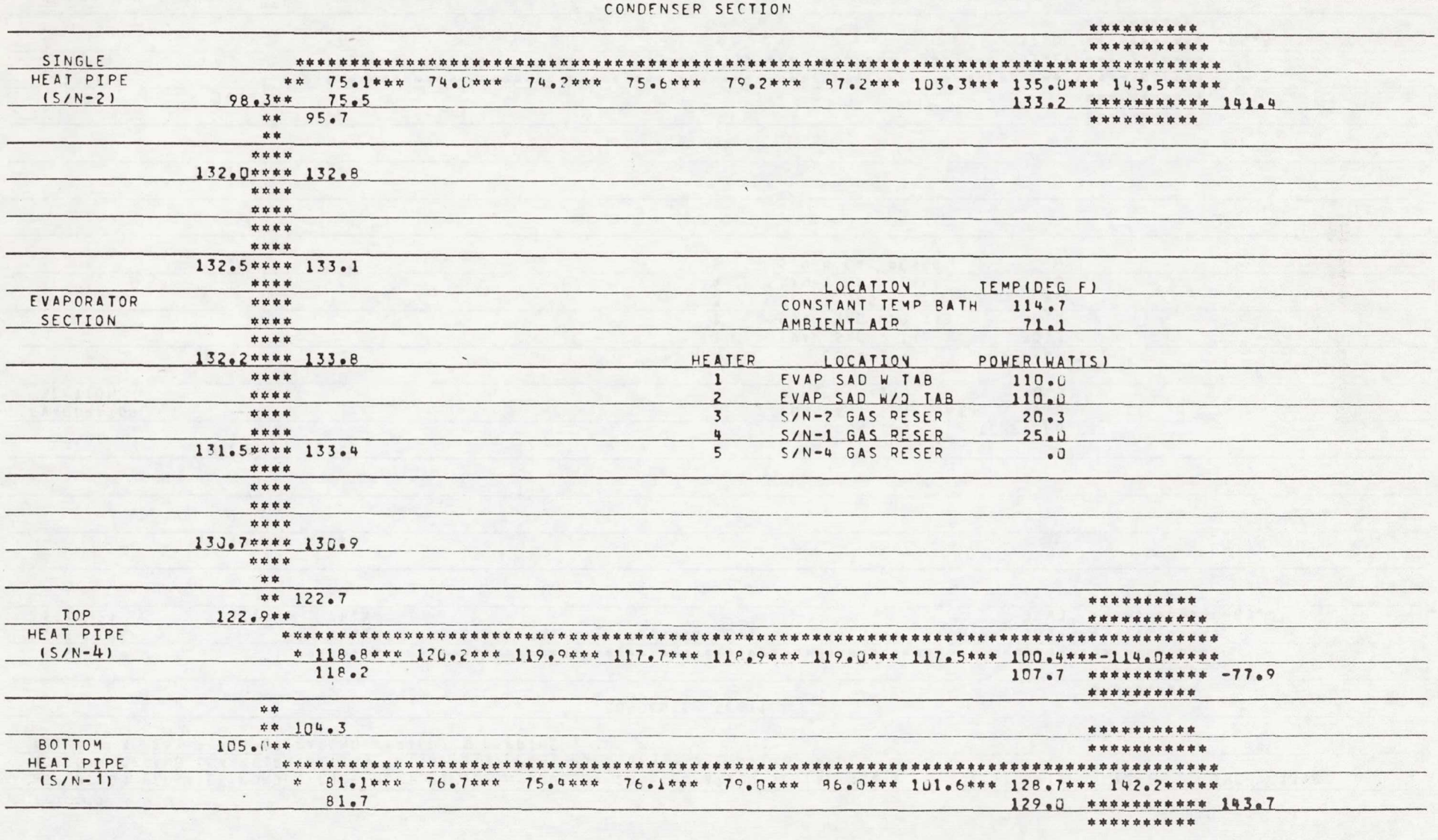
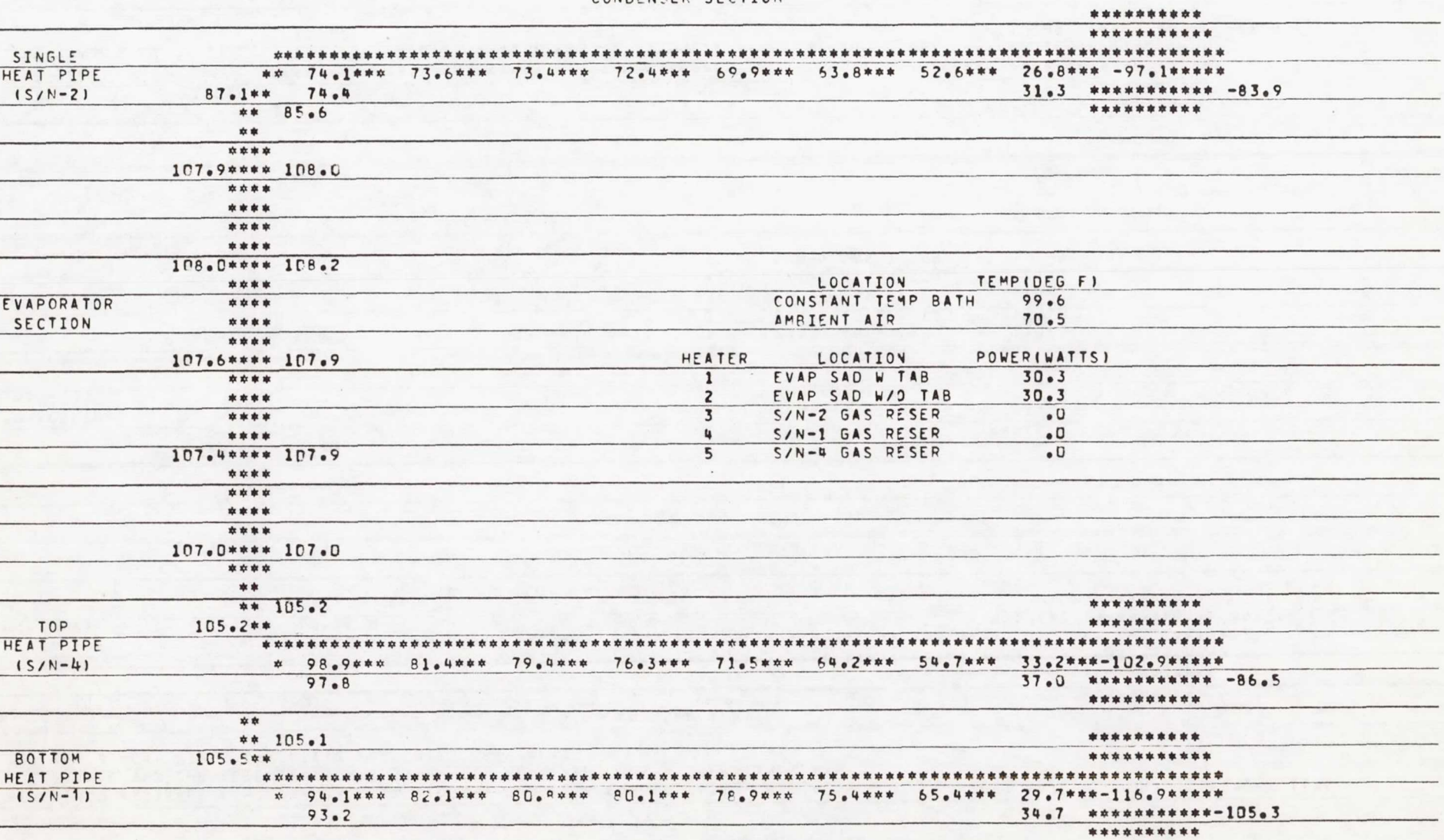


FIGURE A-9.15

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72479 TIME = 1340
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING, AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

CONDENSER SECTION



LOCATION	TEMP(DEG F)
CONSTANT TEMP BATH	99.6
AMBIENT AIR	70.5

HEATER	LOCATION	POWER(WATTS)
1	EVAP SAD W TAB	30.3
2	EVAP SAD W/O TAB	30.3
3	S/N-2 GAS RESER	.0
4	S/N-1 GAS RESER	.0
5	S/N-4 GAS RESER	.0

EVAPORATOR SECTION

FIGURE A-9.16

SEP RIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72479 TIME = 1625
ACCEPTANCE AND CHARACTERIZATION TESTS---(1) HEAT PIPE S/N-4 OPERATING, AND
(2) ALL 3 HEAT PIPES OPERATING (ARTERIES DEPRIMED)

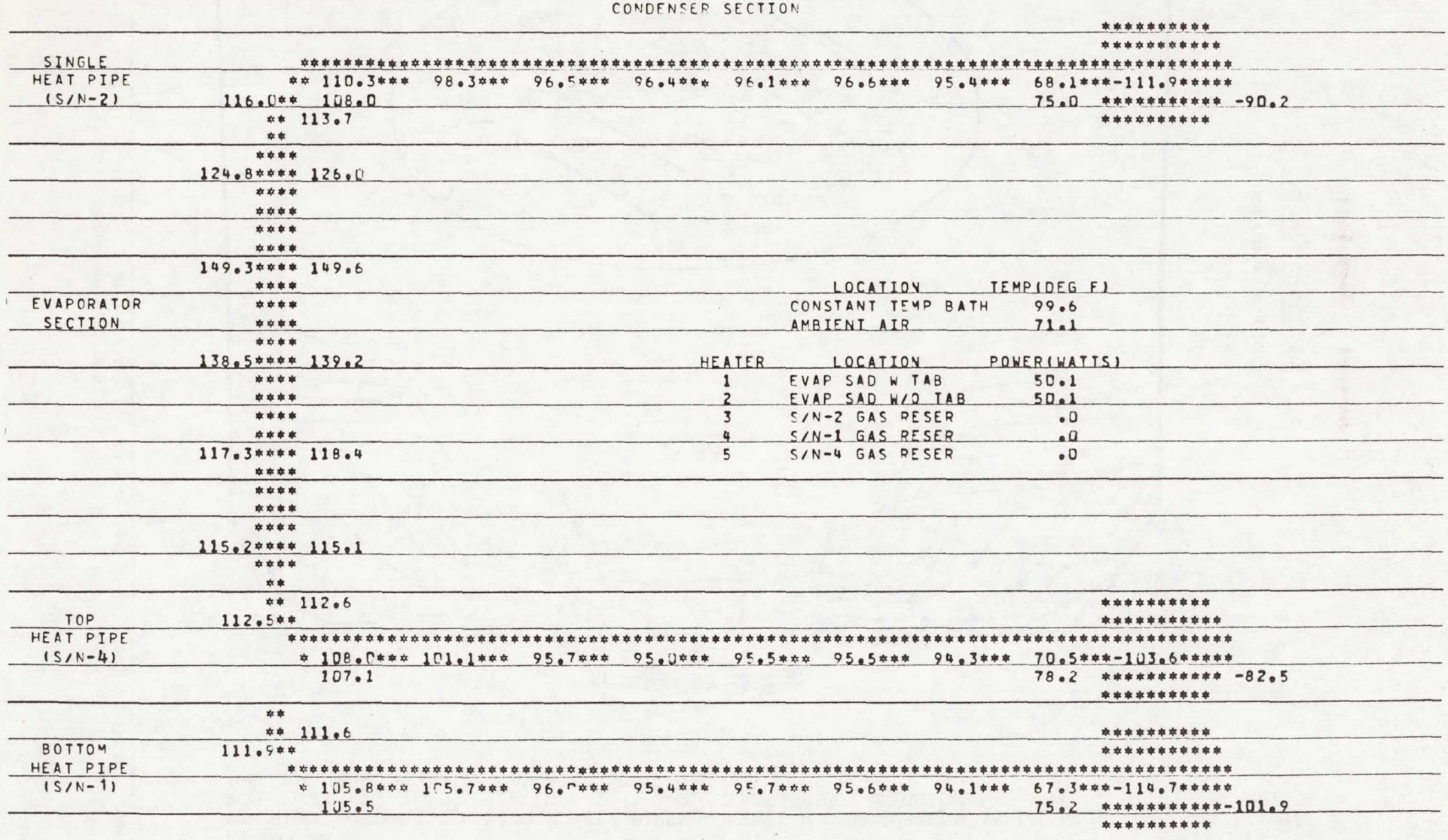


FIGURE A-10.1

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED---WITH VARYING SINK TEMP)

DATE
72579

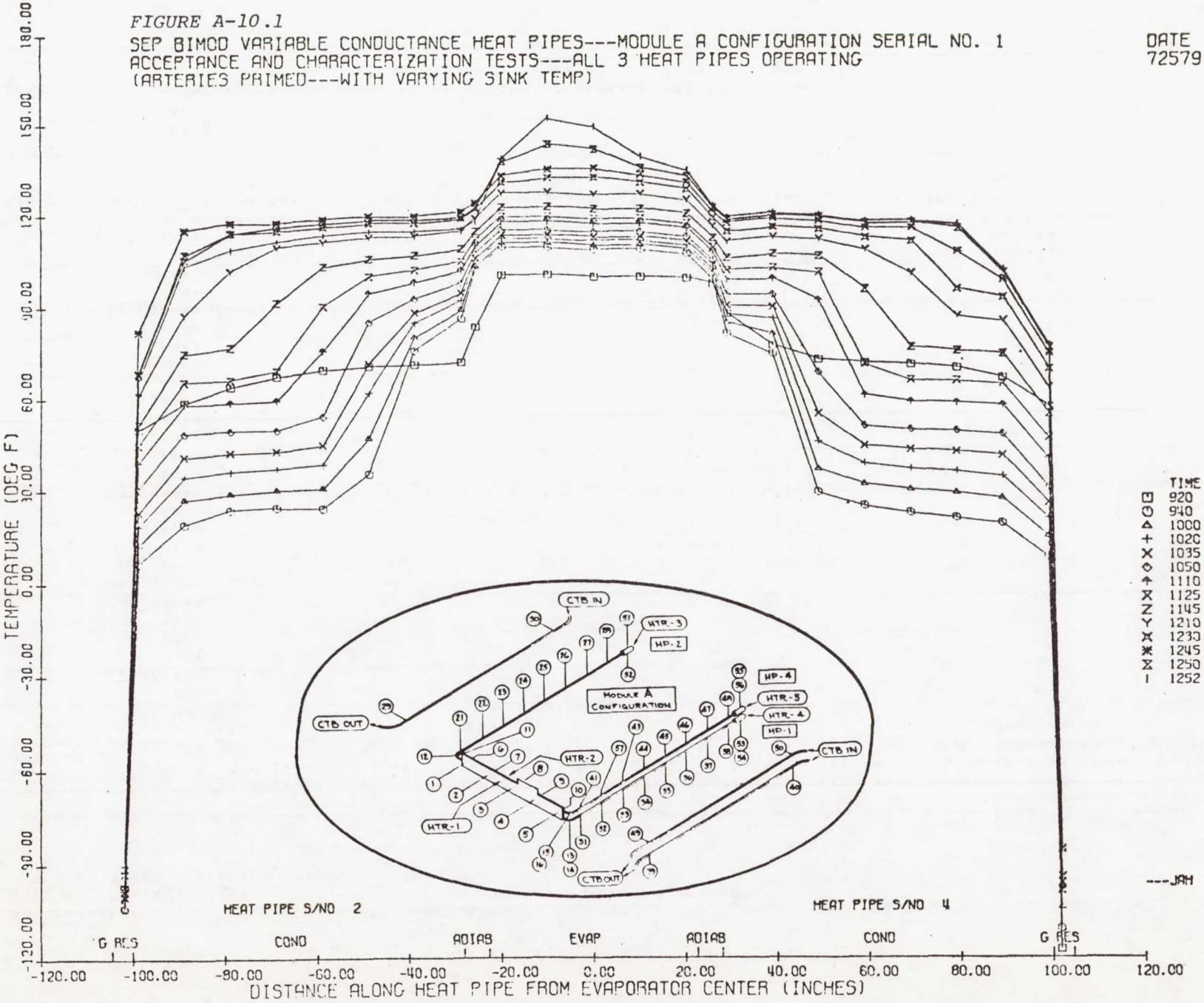


FIGURE A-10.2

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED)---WITH VARYING SINK TEMP)

DATE
72579

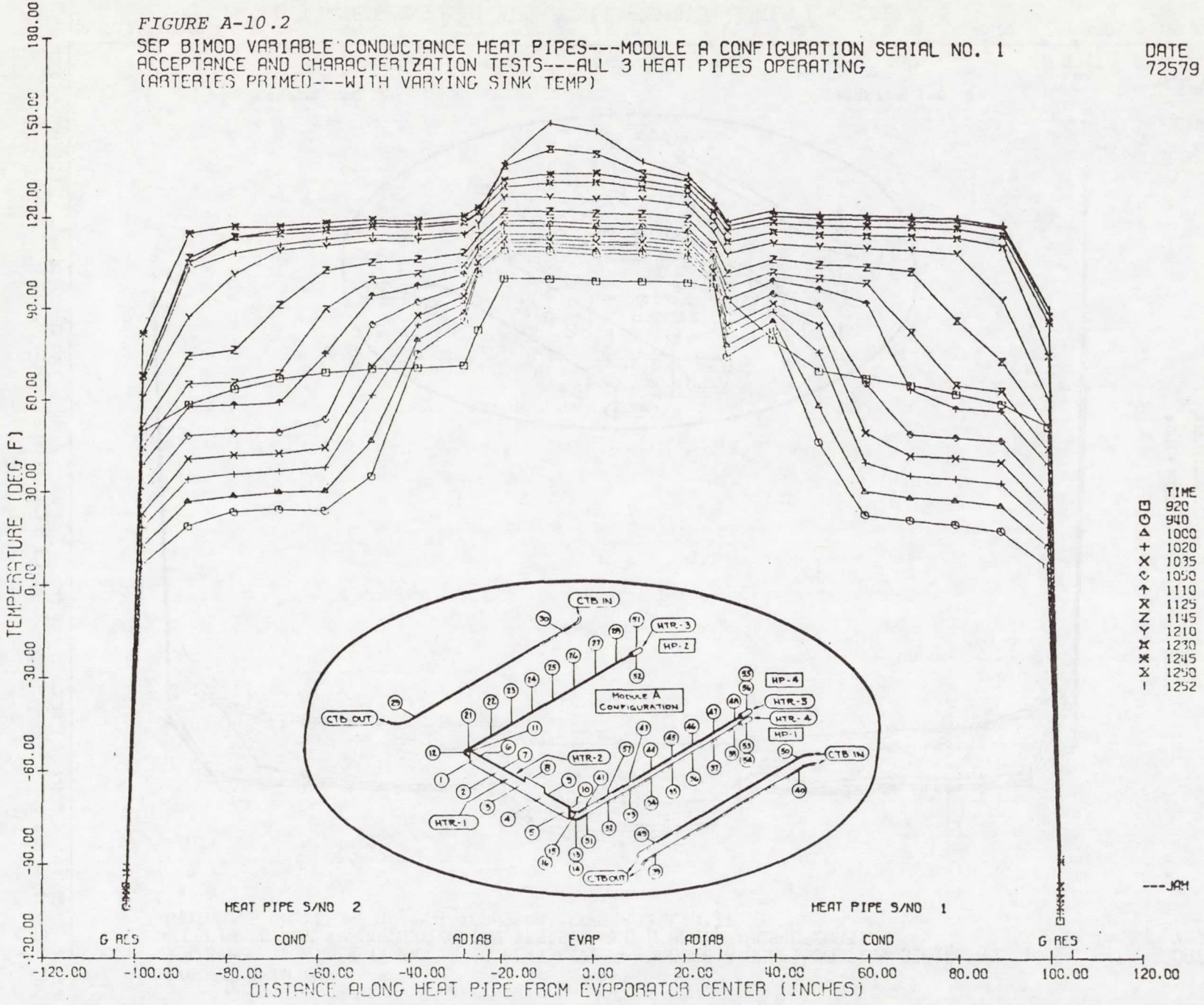


FIGURE A-10.3

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED---TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579

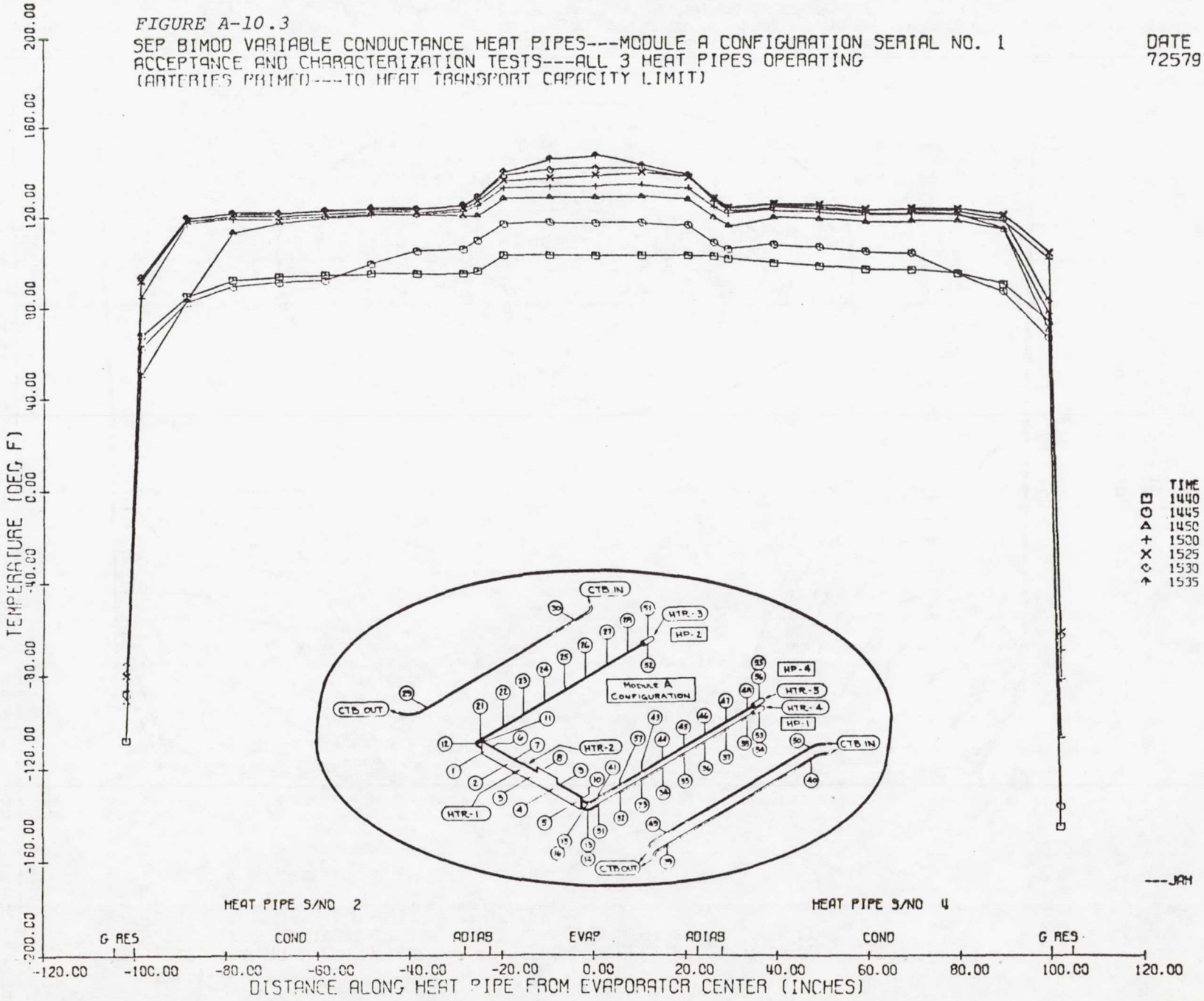


FIGURE A-10.4

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING
(ARTERIES PRIMED---TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579

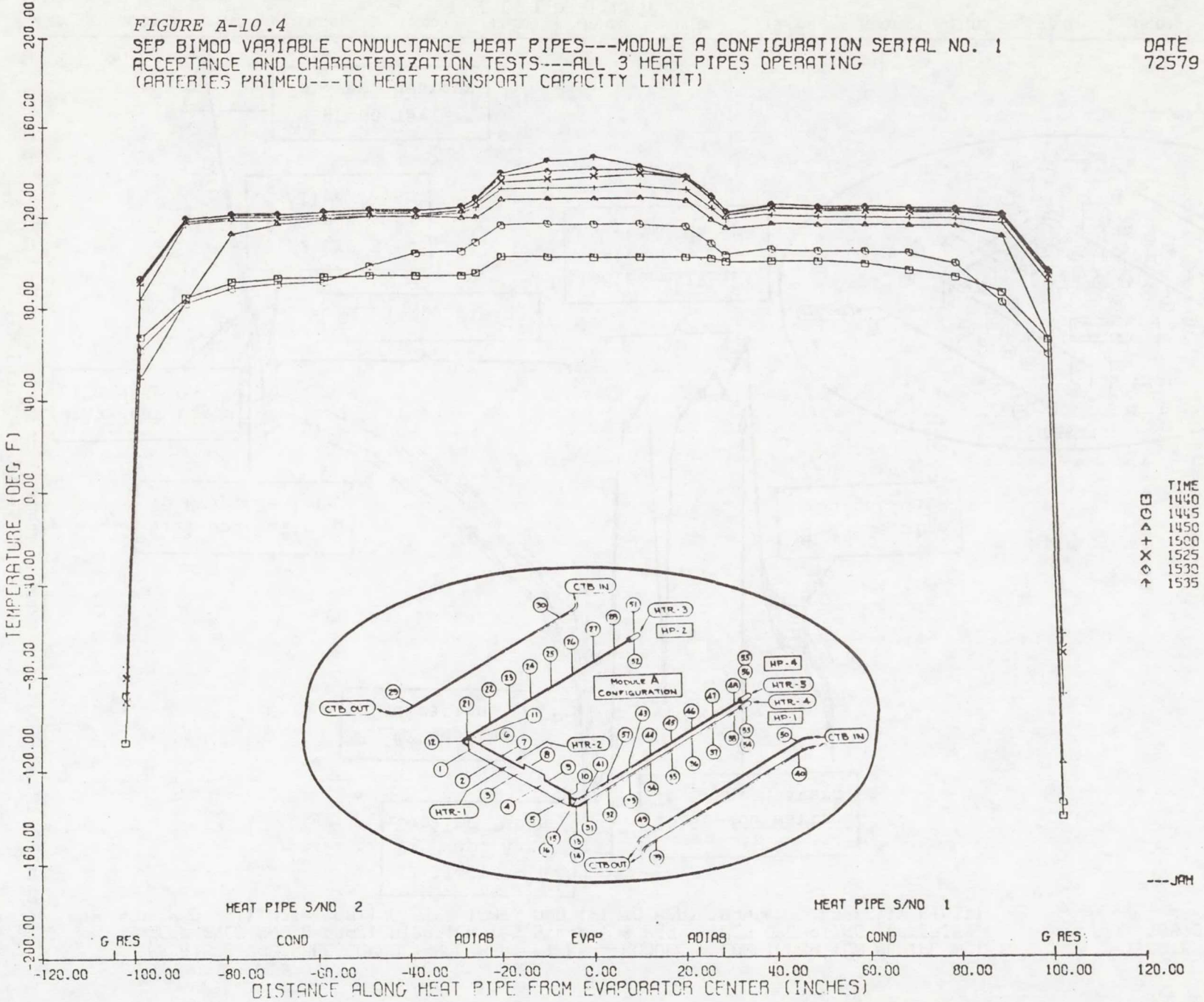


FIGURE A-10.5

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE 72579

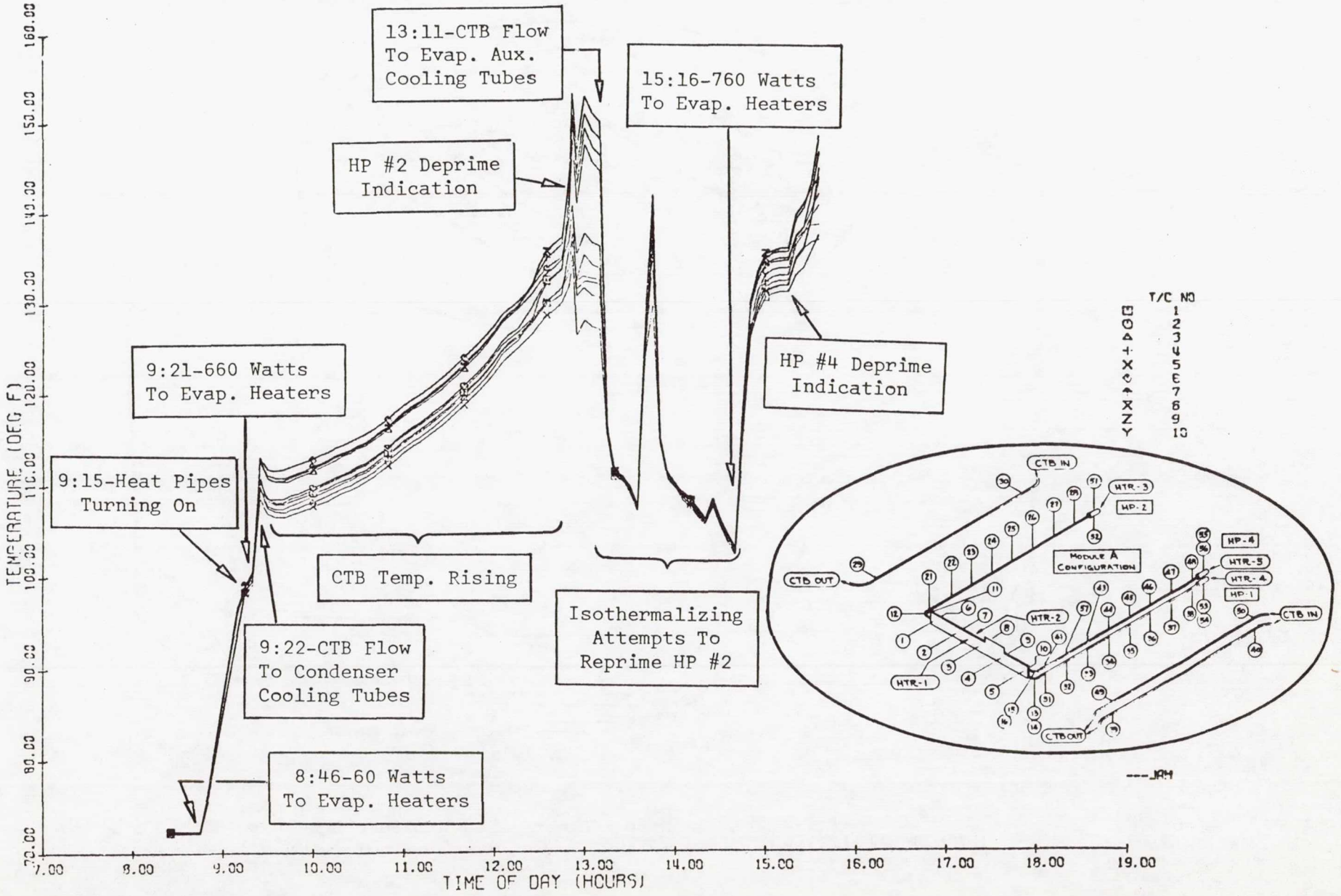


FIGURE A-10.6

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579

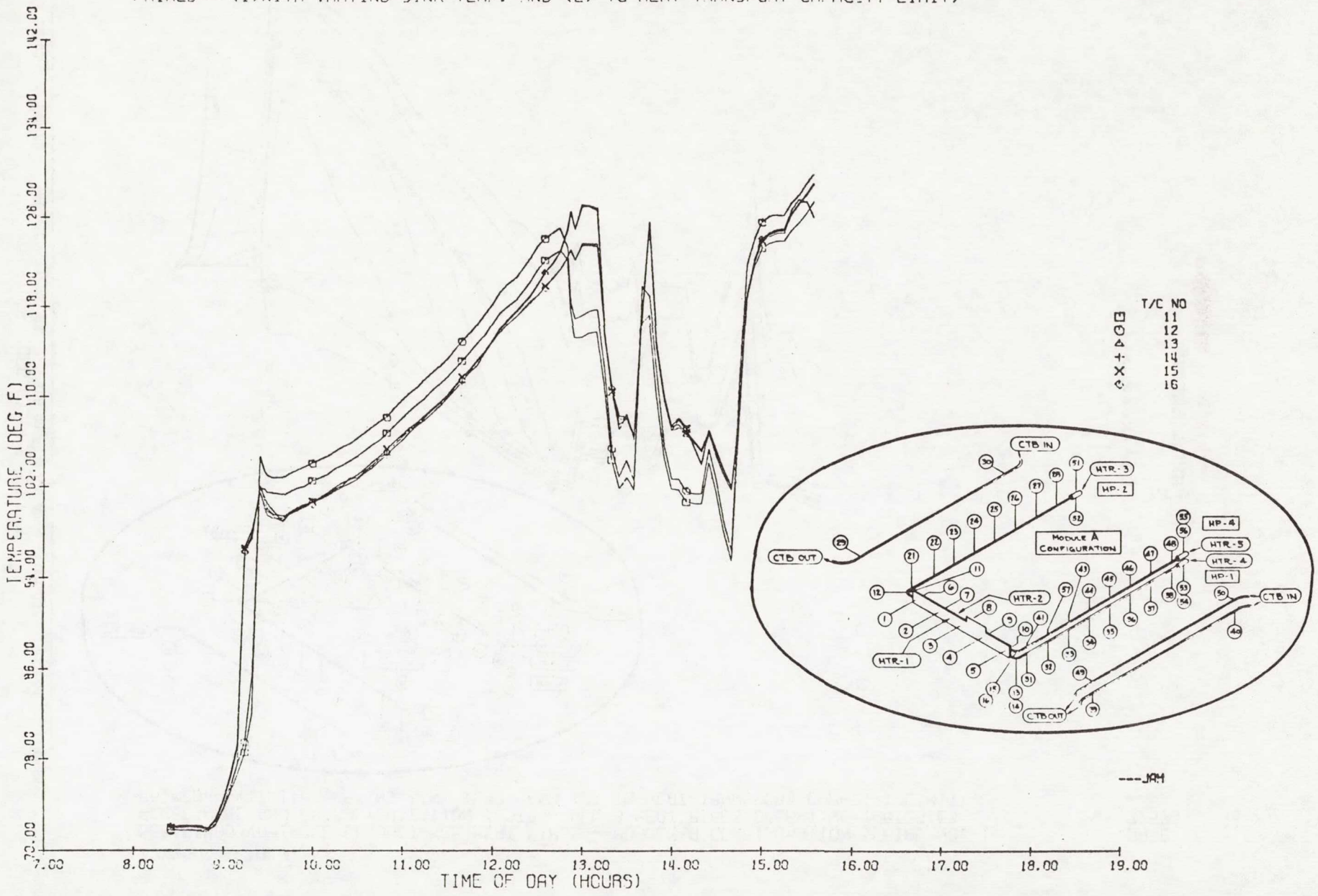


FIGURE A-10.7

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579

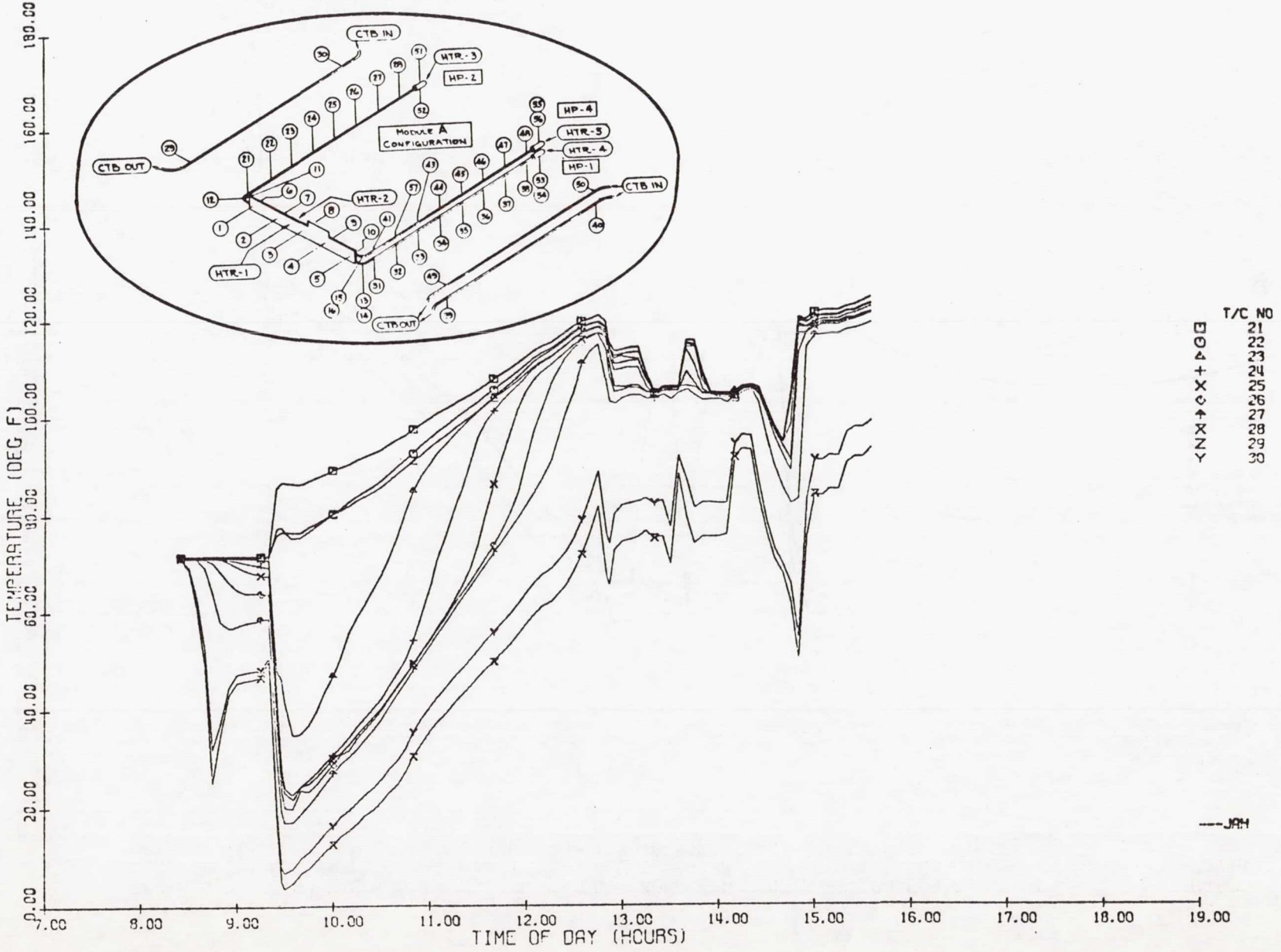
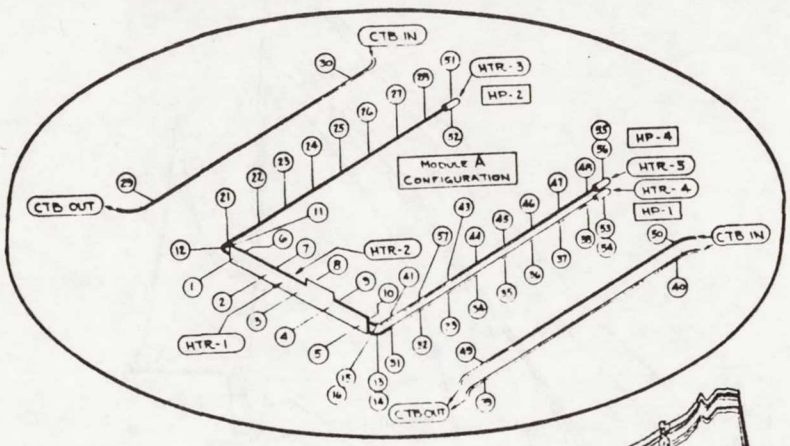


FIGURE A-10.8

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES
PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579



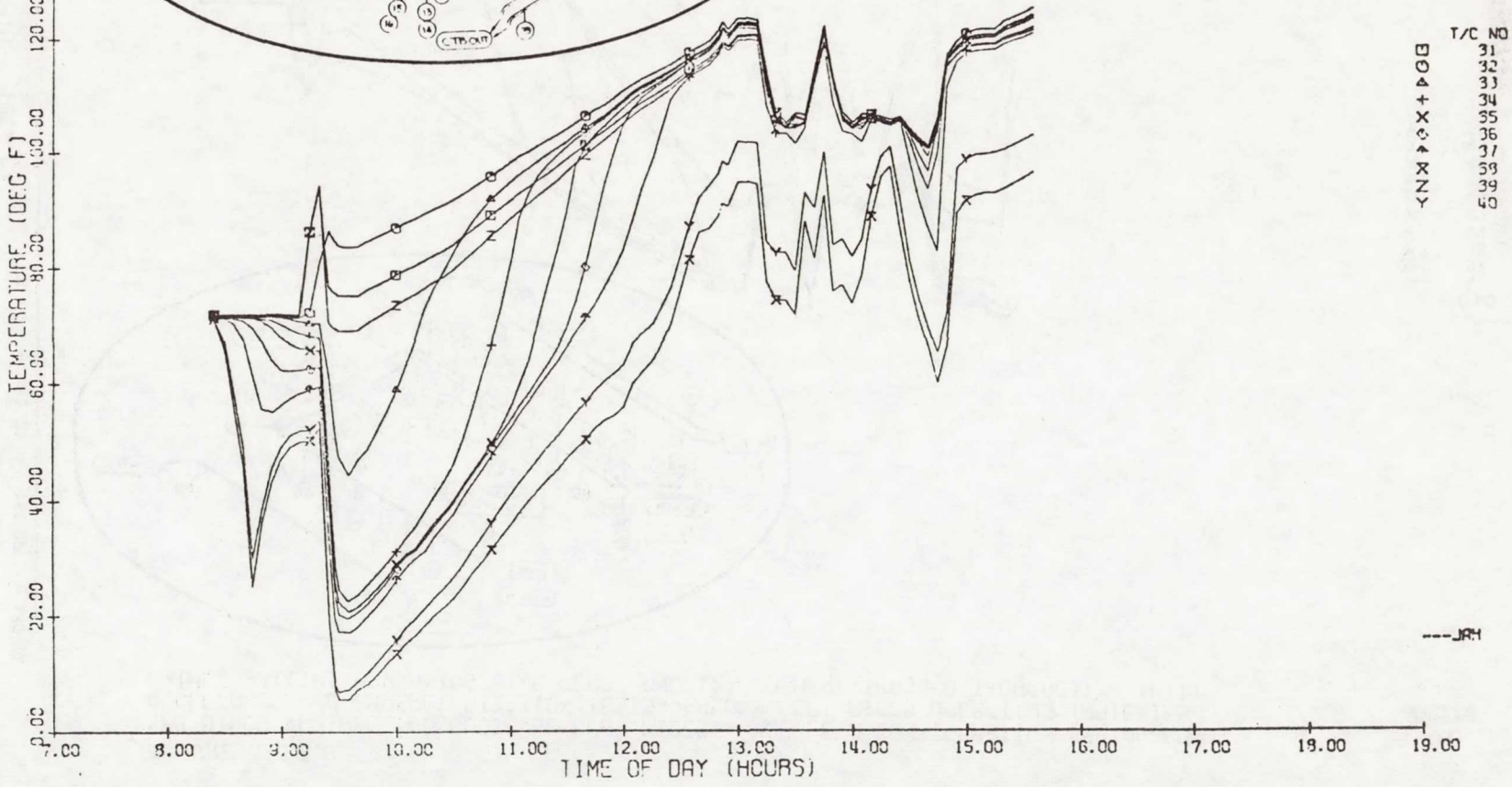


FIGURE A-10.9

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579

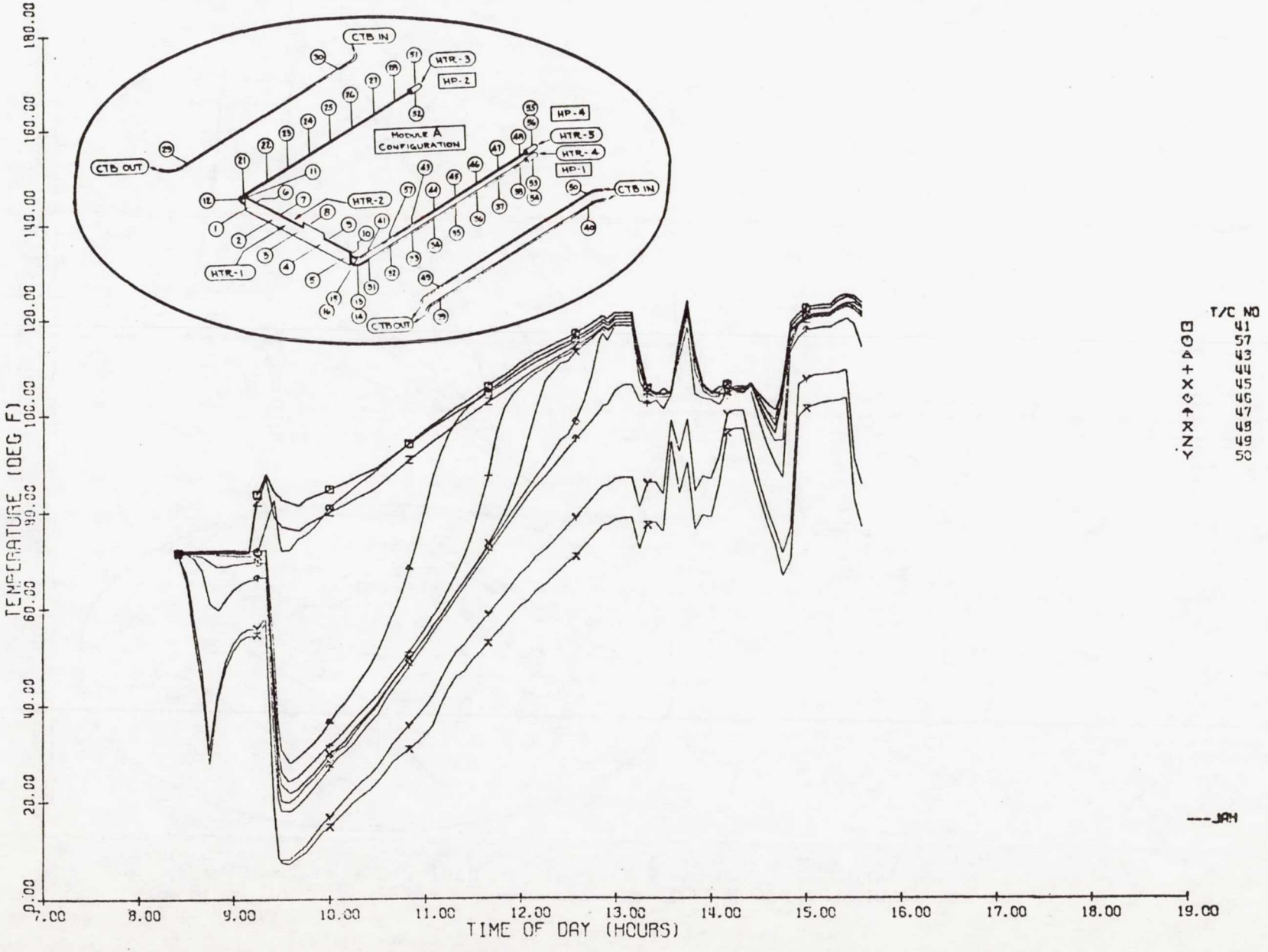


FIGURE A-10.10

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE 72579

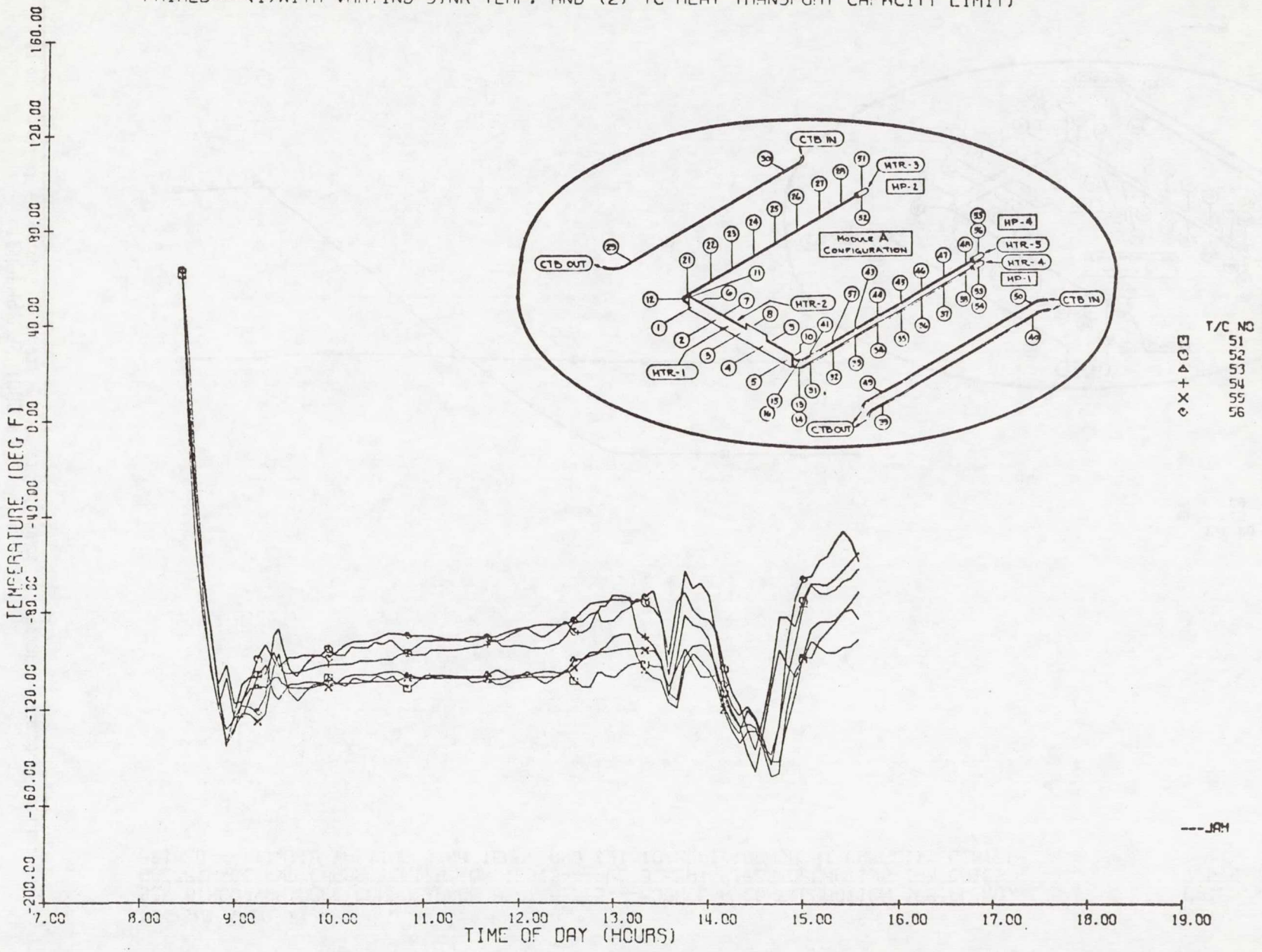


FIGURE A-10.11

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE 72579

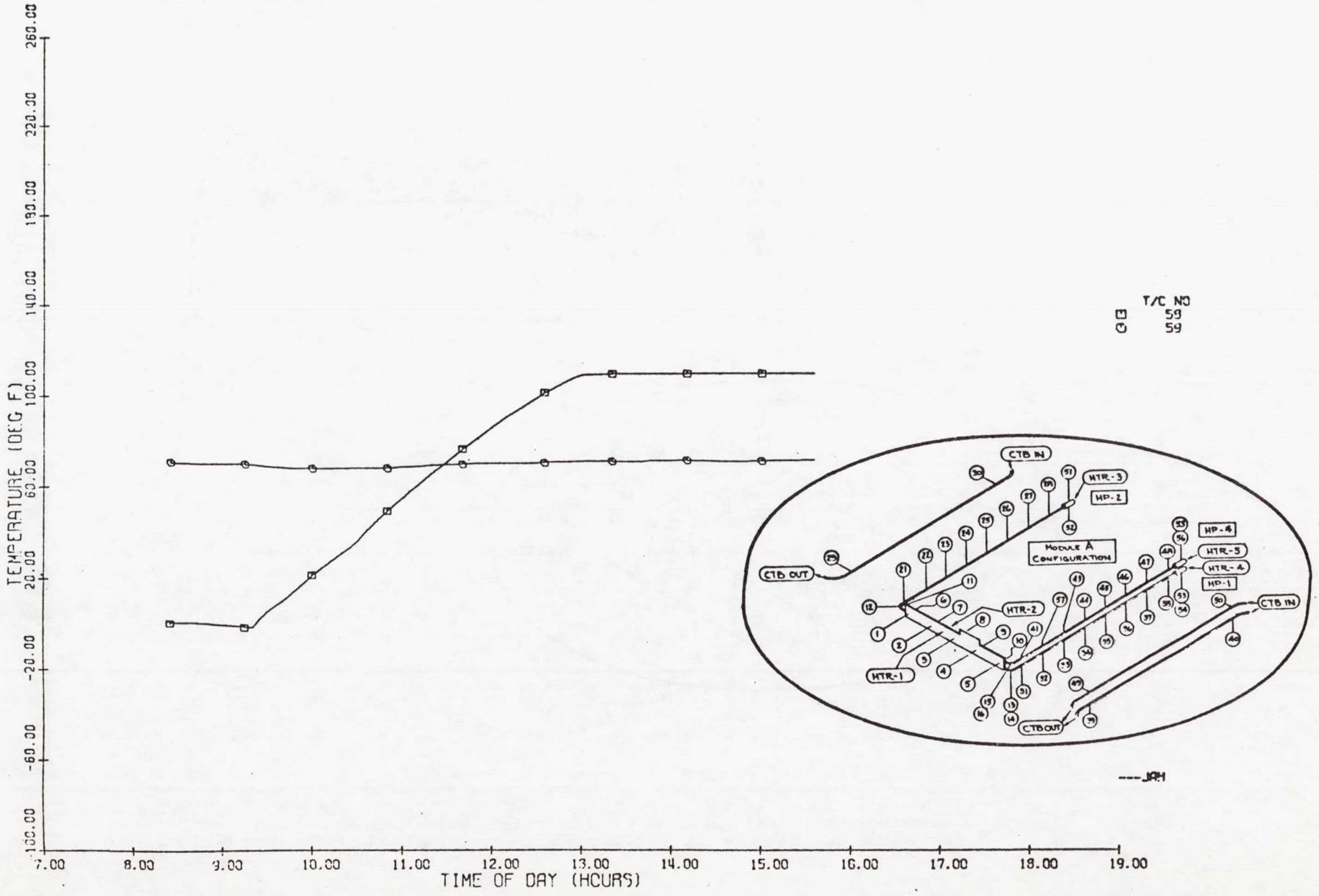


FIGURE A-10.12

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP. AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

DATE
72579

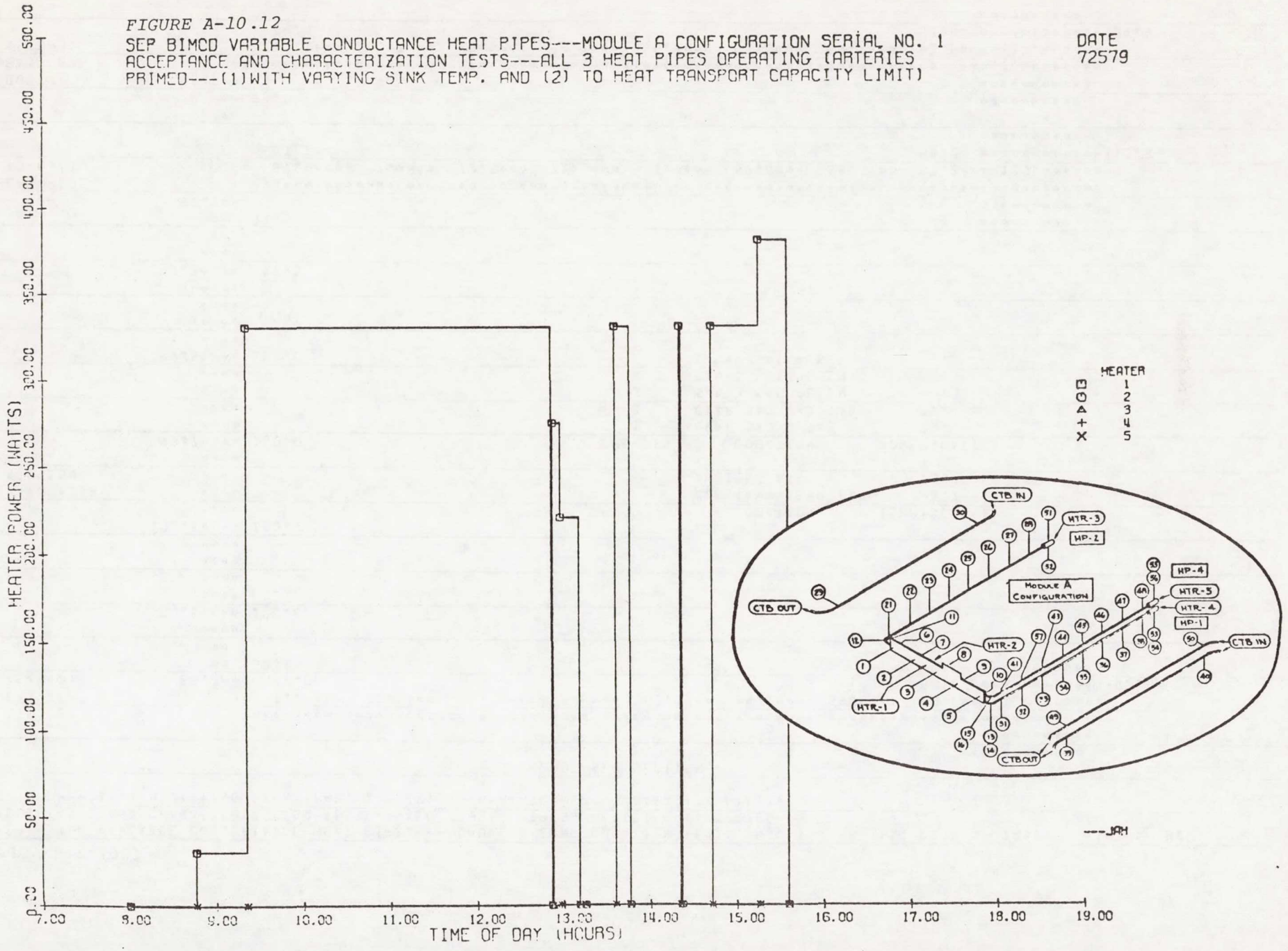


FIGURE A-10.13

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72579 TIME = 920
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP, AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

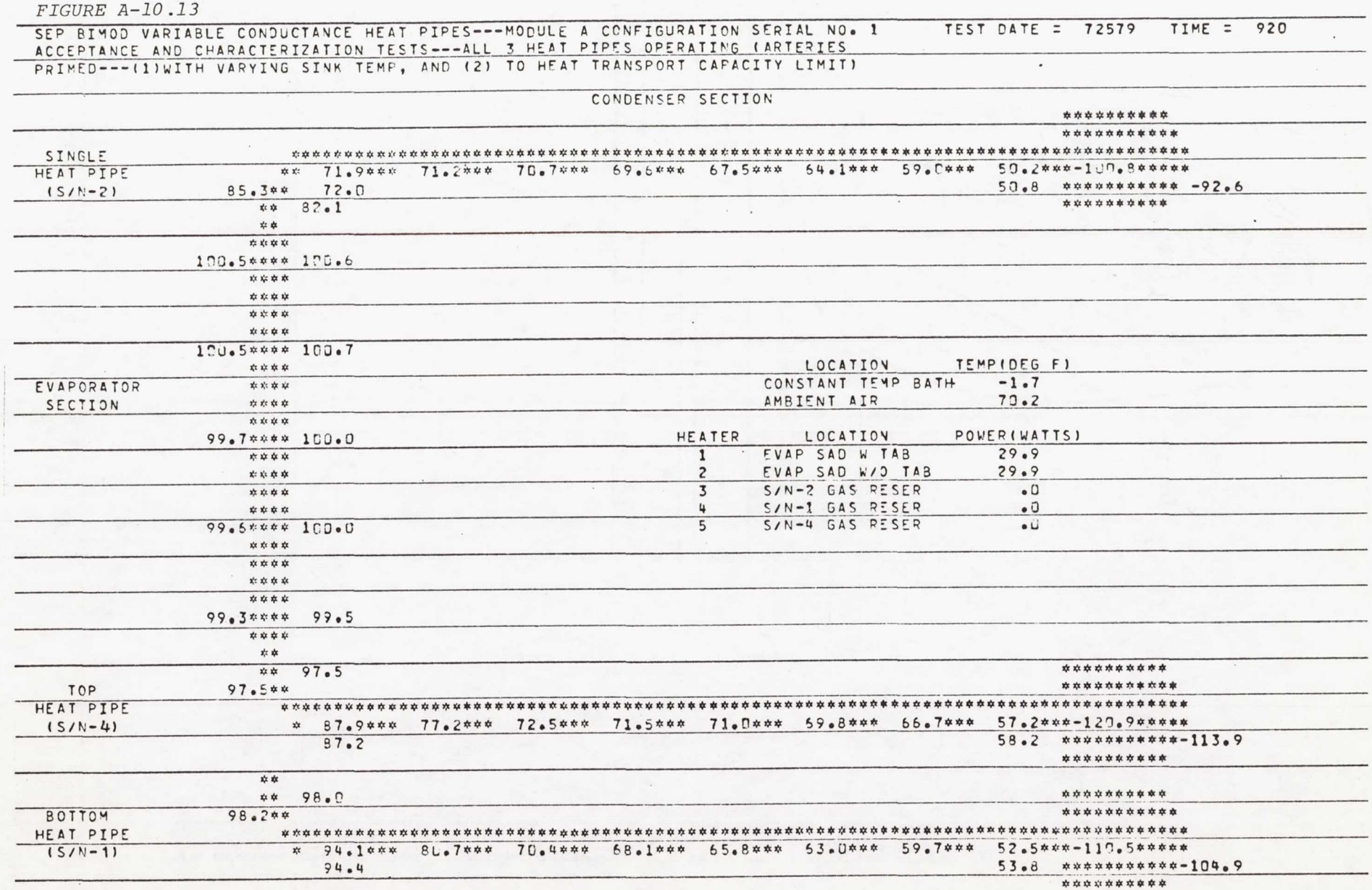


FIGURE A-10.14

SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72579 TIME = 925
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP, AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)

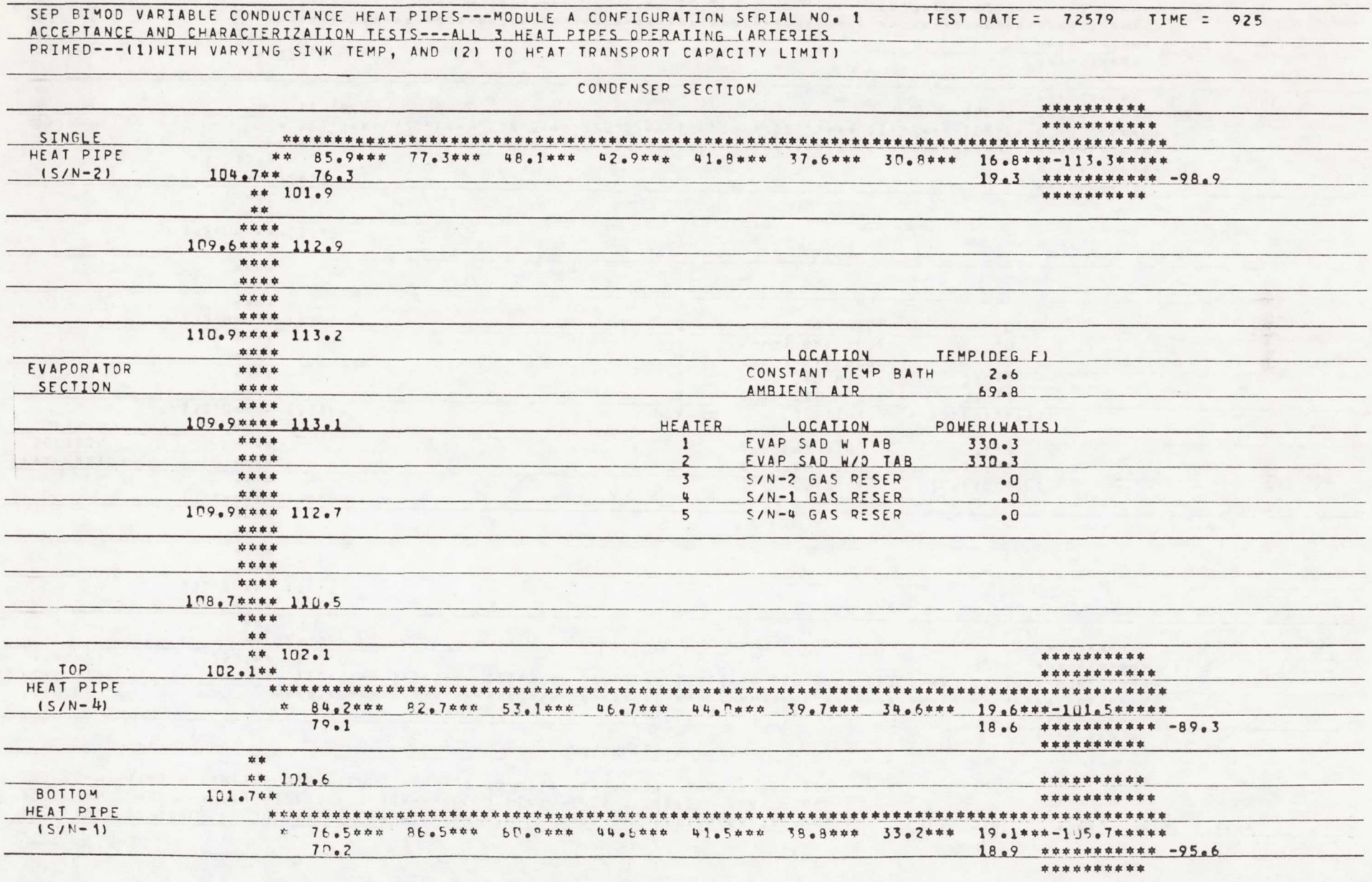
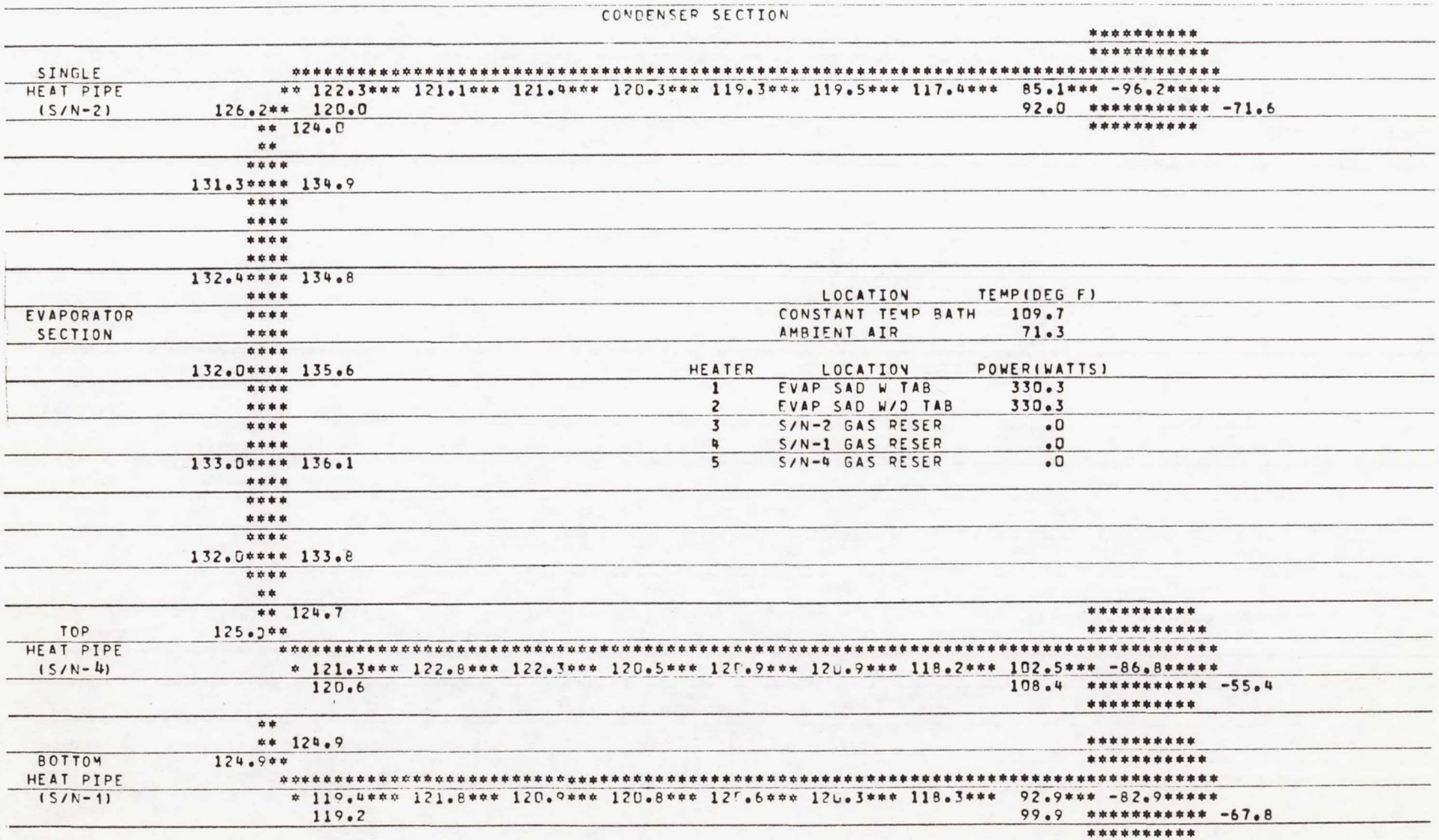
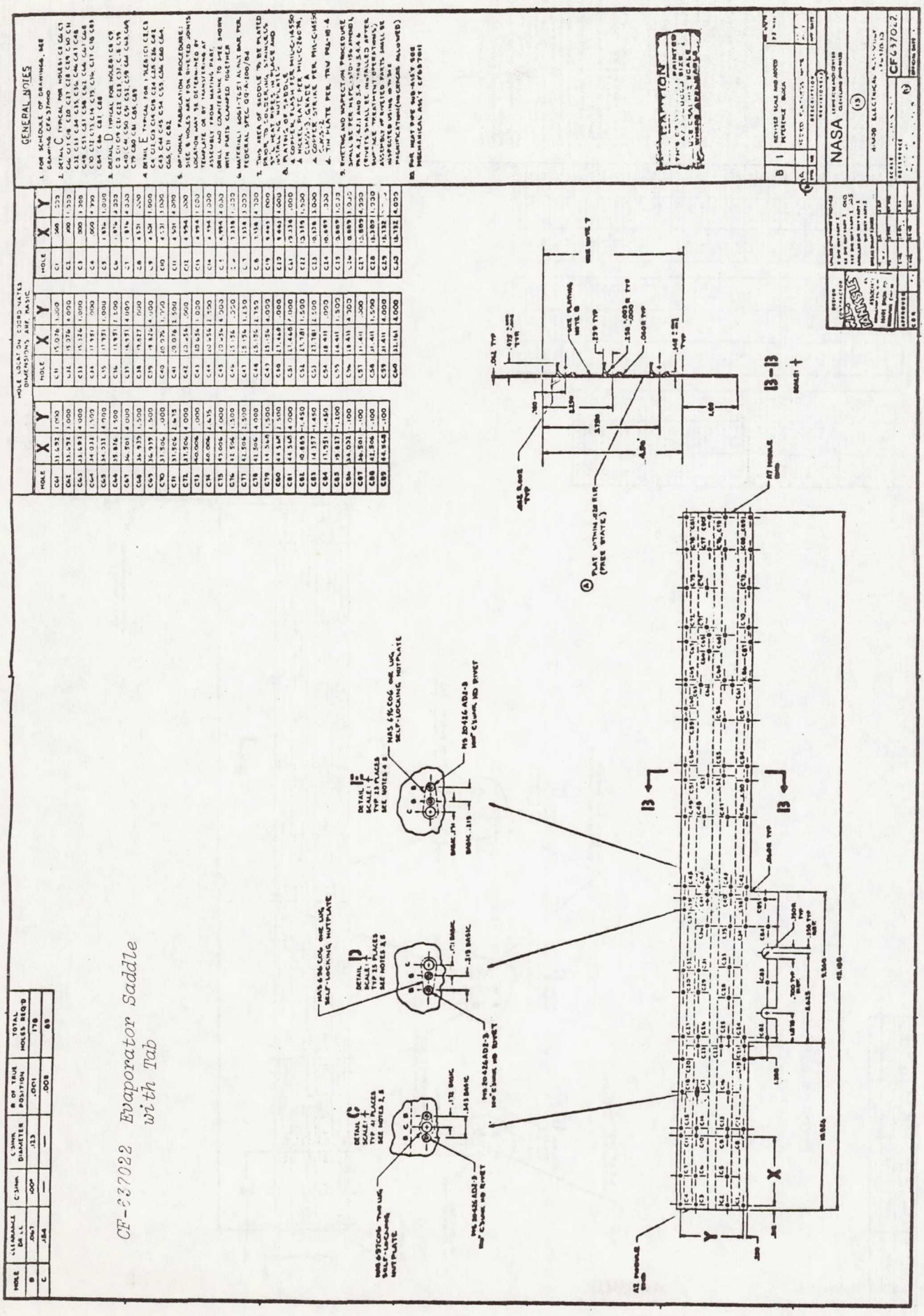


FIGURE A-10.15

SEP RIMOD VARIABLE CONDUCTANCE HEAT PIPES---MODULE A CONFIGURATION SERIAL NO. 1 TEST DATE = 72579 TIME = 1515
ACCEPTANCE AND CHARACTERIZATION TESTS---ALL 3 HEAT PIPES OPERATING (ARTERIES PRIMED---(1)WITH VARYING SINK TEMP, AND (2) TO HEAT TRANSPORT CAPACITY LIMIT)




GENERAL NOTES
NASA
CF-437022 Evaporator Saddle with Tab

HOLE	C'BARANCE DRILL	C'SINK	C'SINK DIAMETER	⌀ OF TRUE POSITION	TOTAL HOLES REQ'D
B	.067	100°	.123	.001	170
C	.154	—	—	.008	88

CF-637023 *Evaporator Saddle Without Tab*

HOLE LOCATION COORDINATES
DIMENSIONS ARE BASIC

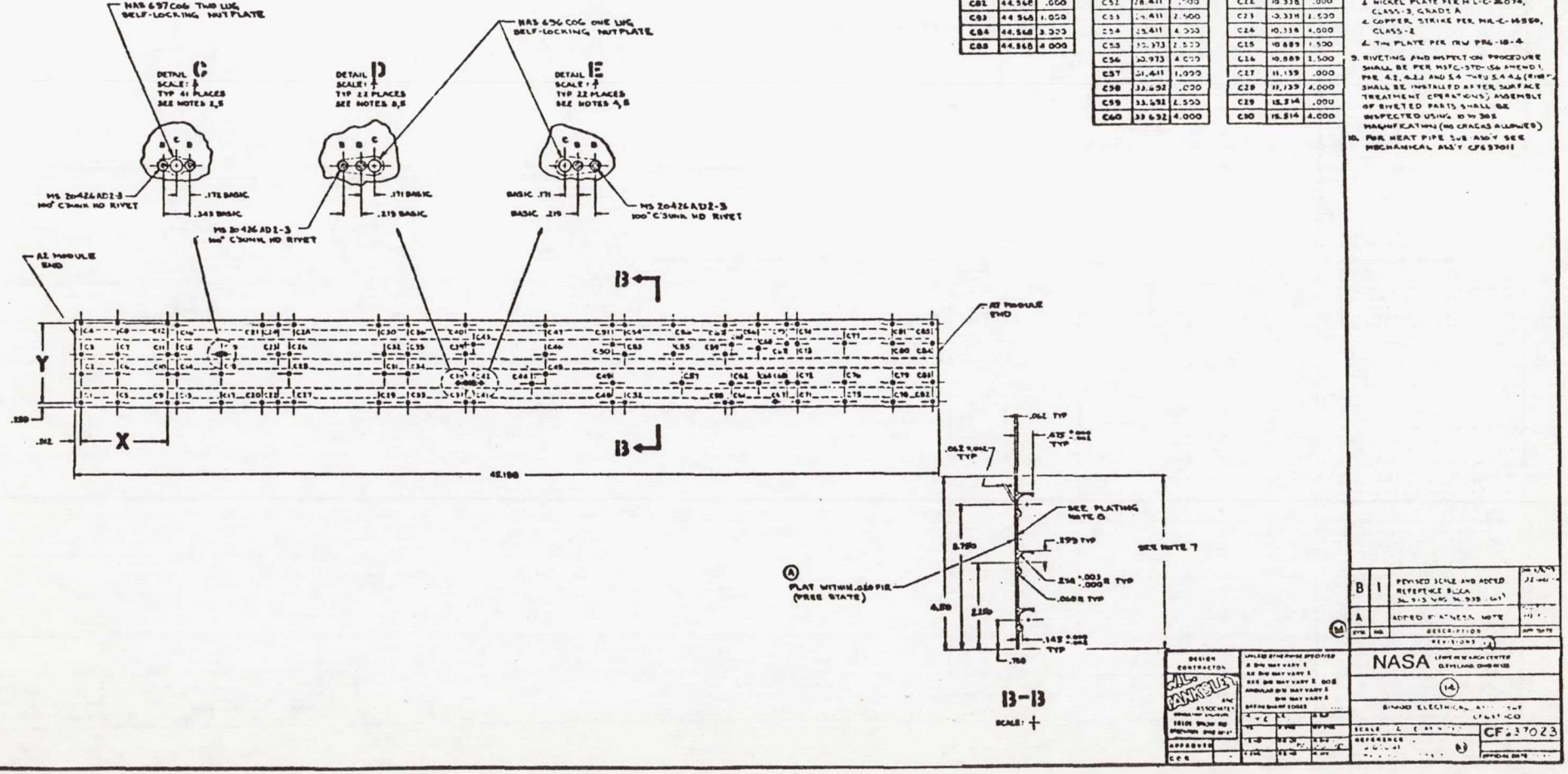
HOLE	X	Y
C61	34.032	.000
C62	34.032	1.000
C63	34.032	3.000
C64	35.439	1.000
C65	35.439	2.850
C66	35.439	4.100
C67	36.515	.000
C68	36.939	.000
C69	36.939	3.000
C70	36.939	4.000
C71	37.506	.000
C72	37.506	.100
C73	37.506	3.000
C74	37.506	4.000
C75	40.006	.000
C76	40.006	1.000
C77	40.006	3.000
C78	42.506	.000
C79	42.506	1.000
C80	42.506	3.000
C81	42.506	4.000
C82	44.568	.000
C83	44.568	1.000
C84	44.568	3.000
C85	44.568	4.000

HOLE	X	Y
C31	5.795	1.500
C32	5.195	2.500
C33	17.014	.000
C34	17.014	1.500
C35	17.014	2.500
C36	17.014	4.000
C37	25.276	.000
C38	25.276	1.200
C39	25.276	2.500
C40	25.276	4.000
C41	28.531	.000
C42	28.531	1.000
C43	28.531	3.000
C44	28.594	1.000
C45	29.681	1.500
C46	29.681	2.500
C47	29.681	4.000
C48	29.781	.000
C49	29.781	1.000
C50	29.781	3.000
C51	29.781	4.000
C52	28.411	.000
C53	28.411	2.500
C54	28.411	4.000
C55	30.973	2.500
C56	30.973	4.000
C57	31.411	1.000
C58	33.692	.000
C59	33.692	2.500
C60	33.692	4.000

HOLE	X	Y
C1	.000	.000
C2	.000	1.930
C3	.000	2.500
C4	.000	4.100
C5	1.876	.000
C6	1.876	1.500
C7	1.876	2.500
C8	1.876	4.100
C9	4.501	.000
C10	4.501	1.500
C11	4.501	2.500
C12	4.501	4.100
C13	4.994	.000
C14	4.994	1.500
C15	4.994	2.500
C16	4.994	4.000
C17	7.339	.000
C18	7.338	1.500
C19	7.338	2.500
C20	9.463	.000
C21	9.463	4.000
C22	10.338	.000
C23	10.338	1.500
C24	10.338	4.000
C25	10.889	1.500
C26	10.889	2.500
C27	11.139	.000
C28	11.139	4.000
C29	15.314	.000
C30	15.314	4.000

GENERAL NOTES

1. FOR SCHEDULE OF DRAWINGS SEE DRAWING CF637000
2. DETAIL C TYPICAL FOR HOLES: C5 C6 C7 C8 C13 C18 C19 C22 C23 C24 C25 C29 C30 C31 C32 C33 C34 C35 C36 C40 C44 C45 C46 C47 C49 C50 C54 C55 C56 C57 C60 C62 C64 C65 C66 C75 C76 C77 C78 C79 C80 C84
3. DETAIL D TYPICAL FOR HOLES: C9 C10 C11 C12 C20 C21 C26 C27 C38 C39 C48 C51 C58 C59 C67 C68 C69 C70 C82 C83 C94 C85
4. DETAIL E TYPICAL FOR HOLES: C1 C2 C3 C4 C14 C15 C16 C17 C28 C29 C41 C42 C43 C52 C53 C61 C63 C71 C72 C73 C74
5. OPTIONAL FABRICATION PROCEDURE: SIDE B HOLES ARE FOR RIVETED JOINTS. LOCATION MAY BE DETERMINED BY TEMPLATE OR BY TRANSFERRING AT ASSEMBLY FROM MATING PART. DRILL AND COUNTERSINK TO SIZE SHOWN WITH PARTS CLAMPED TOGETHER.
6. MATERIAL: 6061-T651 ALBLT BAR PER FEDERAL SPEC QQ-A-200/8d
7. THIS AREA OF SADDLE TO BE PLATED PRIOR TO SOLDERING STAINLESS STL HEAT PIPES IN PLACE AND INSTALLING NUTPLATES.
8. PLATING OF SADDLE
   A. COPPER FLASH PER MIL-C-14550
   B. NICKEL PLATE PER M L-C-26074, CLASS-3, GRADE A
   C. COPPER STRIKE PER MIL-C-14550, CLASS-2
   D. TIN PLATE PER IRW PR6-18-4
9. RIVETING AND INSPECTION PROCEDURE SHALL BE PER MSFC-STD-164 AMEND 1, PAR 4.2, 4.2.1 AND 5.4 EXCEPT U.S.4.4.6 (RIVET) SHALL BE INSTALLED AFTER SURFACE TREATMENT OPERATIONS) ASSEMBLY OF RIVETED PARTS SHALL BE INSPECTED USING 10 TO 30X MAGNIFICATION (NO CRACKS ALLOWED)
10. FOR HEAT PIPE SUB ASSY SEE MECHANICAL ASSY CF637011



B	1	REVISED SCALE AND ADDED REFERENCE BLOCK	
A		ADDED FLATNESS NOTE	
SYM	NO.	DESCRIPTION	APP DATE

REVISIONS

DESIGN CONTRACTOR: MAC DANIELS AND ASSOCIATES, 10801 SHAW RD, BROOKPARK, OHIO 44142

APPROVED

C.O.S.

UNLESS OTHERWISE SPECIFIED
X DIM MAY VARY ±
XX DIM MAY VARY ±
SEE DIM MAY VARY ± .005
ANGULAR DIM MAY VARY ±
DIM MAY VARY ±
BREAK SHARP EDGES

NASA LEWIS RESEARCH CENTER CLEVELAND, OHIO 44135

BENDIX ELECTRICAL ASSEMBLY

SCALE: CF-637023

REFERENCE

OFFICIAL DATE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM-82635		

4. Title and Subtitle	5. Report Date
SEP BIMOD VARIABLE CONDUCTANCE HEAT PIPES ACCEPTANCE AND CHARACTERIZATION TESTS	August 1981
	6. Performing Organization Code 506-55-22
7. Author(s)	8. Performing Organization Report No.
Joseph A. Hemminger	E-857
	10. Work Unit No.
9. Performing Organization Name and Address	11. Contract or Grant No.
National Aeronautics and Space Administration Lewis Research Center Cleveland, Ohio 44135	
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Technical Memorandum
National Aeronautics and Space Administration Washington, D. C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

A series of six heat pipes, similar in design to those flown on the Communications Technology Satellite Hermes, were fabricated and tested by TRW Space Systems Group for use by NASA Lewis Research Center in a prototype Solar Electric Propulsion BIMOD thrust module. This report documents the results of acceptance and characterization tests performed on the heat pipe subassemblies following their delivery to NASA. The performance of all the heat pipes met, or exceeded, design specifications.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Heat pipes; Thermal control; Power processing unit; Solar electric propulsion	Unclassified - unlimited STAR Category 34

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified		

* For sale by the National Technical Information Service, Springfield, Virginia 22161

National Aeronautics and
Space Administration

Washington, D.C.
20546

Official Business

Penalty for Private Use, $300

SPECIAL FOURTH CLASS MAIL
BOOK

Postage and Fees Paid
National Aeronautics and
Space Administration
NASA-451

U.S. MAIL

NASA

POSTMASTER: If Undeliverable (Section 158 Postal Manual) Do Not Return